SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS

OCTOBER 2014

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ARCC

African and Latin American Resilience to Climate Change Project

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AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

OCTOBER 2014

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ACRONYMS AND ABREVIATIONS

AG	Crop-dependent (household)
ARCC	African and Latin American Resilience to Climate Change
CADL	*Centre d'Appui au Développement Local* (Centre for Local Development)
CIRAD	*Centre de coopération internationale en recherche agronomique pour le développement*
CMIP5	Coupled Model Inter-comparison Project Phase 5
CR	*Communauté Rurale* (lowest level elected local governmental units)
CSE	*Centre de Suivi Ecologique* (Center for Ecological Monitoring)
CSO	Civil society organization
DRDR	*Direction Régionale du Développement Rural* (Regional Rural Development Directorate)
ENDA LEAD	*Environnement et développement du Tiers Monde* (Environmental Action in the Third World)
EX	Exposure
FAO	Food and Agriculture Organization of the United Nations
FEWS NET	Famine Early Warning Network
FGD	Focus group discussion
GCM	General Circulation Model
GOANA	Grand Offensive on Food Security
GRDR	*Groupe de Recherche et de Réalisation pour le Développement Rural* (The Research Action Group for Rural Development)
IPCC	Intergovernmental Panel on Climate Change
ISRA	*Institut Sénégalais de Recherches Agricoles* (the Senegalese Institute for Agricultural Research)
ISRA/BAME	Institut Sénégalais de Recherches Agricoles/*Bureau d'Analyse Macro Economique* (Bureau of Macro-Economic Analysis)
KII	Key Informant Interview
LV	livestock-dependent (household)
MX	Mixed systems
PAPEL	*Projet d'Appui à l'Elevage* (Livestock Support Project)

PAPIL	*Programme d'appui à la petite irrigation locale* (The Small Local Irrigation Schemes Support Project)
PCE	*Projet Croissance Economique* (Economic Growth Project)
PRODAM	*Projet de Développement Agricole de Matam* (Matam Agricultural Development Project)
PROGEDE	*Programme de Gestion Durable et Participative des Energies Traditionnelles et de Substitution* (Sustainable and Participatory Energy Management Project for Senegal)
PNDE 2	National Livestock Development Plan for 2012-2016
SE	Sensitivity
SAED	*Société nationale d'Aménagement des Terres du Delta et de la Vallée* (Agency for the Development of the Senegal Delta and River Valley)
SDDR	*Service Départemental du Développement Rural* (Departmental Rural Development Service)
STEP	Sahelian Transpiration Evaporation and Production
TLU	Tropical Livestock Unit. In this study, cattle were weighted 0.7, and sheep and goats 0.1
WFP	World Food Programme

EXECUTIVE SUMMARY

INTRODUCTION AND RESEARCH FRAMEWORK

In May 2012, upon the request of the U.S. Agency for International Development (USAID), the African and Latin American Resilience to Climate Change (ARCC) program began planning for a climate change vulnerability assessment and options analysis in Senegal. During a scoping visit in Dakar that October, ARCC and USAID/Washington staff, in consultation with USAID/Senegal, the Government of Senegal, and other interested parties, decided that, in order to produce an in-depth assessment, the study would target a limited geographic area and focus on only one sector. Of the various regions under consideration, Eastern Senegal was selected to be studied. This region of the country was selected due to its high level of food insecurity and because it was a potential location for future USAID investment. Further, an initial scoping suggested few, if any, projects specifically focusing on climate change had been implemented in this area. Much of the selected area also falls in the Sahel, potentially making the study more broadly applicable to activities elsewhere in this region. During the research design process, the study was more precisely defined to involve the rural pastoral and rain-fed farming areas of four departments in Senegal: Matam, Kanel, Goudiry, and Bakel.

The study area straddles several different agro-ecological zones, with livestock raising playing a greater role in livelihoods in the more arid North. In the more humid South, communities rely more on crop farming and forest resources. Research elsewhere in Africa suggests that livestock production, given its inherent mobility, is better adapted to a changing climate than crop agriculture. With these and other characteristics of the study zone in mind, during the months following the scoping mission, the ARCC team developed the following research framework in consultation with USAID:

Purpose: To identify the various causes of climate change vulnerability of the households in the study zone, and, of those causes, identify those for which there is potential for a viable remedy through USAID programming.

Hypothesis: Households with livelihoods that include livestock are less vulnerable to climate change than are households whose livelihoods primarily depend on crop agriculture.

Principal research question: What are the most effective strategies for improving resilience of households to climate change?

Vulnerability Questions:

- In the study zone, households of which of the three production systems being studied (crop-dominant, mixed, livestock-dominant) is most vulnerable to climate variability?
- How will the relative vulnerability of households that depend on each of the different livelihood strategies being considered change in the short term and in the long term?
- What key factors make households of the different livelihood strategies vulnerable?

Adaptation Options Questions:

- What adaptive strategies are available to households of the study zone, and how well will they reduce vulnerability to climate change in the short term and in the long term?

- What are the institutional options for strengthening successful local adaptation?
- What are the research and extension options for strengthening local adaptation?

The above hypothesis was selected for its relevance to the region being studied and because resolving this hypothesis will require the exploration of issues relevant to national policy in Senegal as well other countries in the Sahel. If proven correct, this hypothesis would bolster the idea that those who raise livestock across the study zone will have a comparative advantage as the climate changes. Resolving this hypothesis requires an assessment of the vulnerability of crop agriculture, particularly in the northern portion of the study zone, and weighing the possibility that long-term climate change might undermine the viability of crops currently grown there. This hypothesis also directs analysis to the various reasons why livestock systems might maintain this advantage, and in particular the relative importance of livestock mobility in mitigating vulnerability. Finally, this hypothesis and the research questions derived from it drive the assessment to elucidate some of the most critical issues related to climate change in the study zone and provide decision makers with a broad foundation of information so that they can generate informed options to resolve them. It clarifies how to reduce the vulnerability of households dependent on crop agriculture, as well as how to reduce the vulnerability of both mobile and sedentary livestock systems.

Analytical approach

The analytical approach for the assessment draws on the 2007 Intergovernmental Panel on Climate Change (IPCC) definition of climate change vulnerability as a function of exposure, sensitivity, and adaptive capacity. For the purposes of this assessment, the components of vulnerability are defined as follows:

- Exposure: biophysical limits imposed by climate, specifically the constraints to cropping and livestock systems produced by rainfall and temperature patterns. These parameters are largely beyond human control.
- Sensitivity: the relative dependence of households on climate-affected production systems.
- Adaptive capacity: the ability of households to modify their circumstances or behavior so as to successfully adjust to existing and anticipated external climate trends and shocks. This component is measured both through household assets and through signs of livelihood stress.

Research methods

The principal methods used to implement the approach described above consist of focus group discussions among women and men of 15 villages of the study zone, a household survey of 450 households in those same villages, 40 key informant interviews of the staff of local institutions, the analysis of climate data from five meteorological stations in and around the study zone, and downscaling climate projections for the 2030 and 2050 time horizons. Methods also included crop and livestock resource modeling based on the same climate data, spatial analysis, multiple literature reviews, and consultation with local experts.

Vulnerability assessment findings

This assessment complements recent findings regarding poor health and nutritional status in the zone by providing other indicators of diminished wellbeing. The rural communities in the four studied departments have a limited asset base, which is reflected in low rates of education and high rates of

migration. They face numerous challenges to their production systems, including a deteriorating natural resource base, limited access to inputs and credit, a skeletal road network, and an underdeveloped market system. The communities of this zone rarely receive assistance from external institutions.

Household strategies to address climatic constraints

Rainfall, and to a lesser extent temperature, constrain agricultural production across the study zone. In the North, average annual rainfall levels fall below the optimal growth range for cowpea, sorghum, millet, maize, and groundnut. The considerable variation in the timing of rainfall further reduces the reliability of yields in this sub-zone, where crops are farmed closer to their climatic thresholds. Local climate also impacts pasture available to herders; recent dry and wet years show dramatic variation, especially in the departments of Matam and Bakel. Modeling conducted for this assessment shows that, historically, climatic variation has affected rangeland vegetation more strongly than it has affected crop yields.

Farmers respond to these characteristics of the climate through the crops they cultivate, the composition of their herds, their agricultural management strategies, and the extent to which they seek off-farm income. All households in the North cultivate more cowpeas relative to other crops, while those in the South depend more on groundnuts and maize. Households in the North that rely more on livestock hold a larger proportion of their herds in small ruminants, which are better adapted to high temperature and limited pasture conditions. Livestock owners in the North also manage their animals differently, relying more on herd mobility than livestock owners do in the South. All households in the study zone derive a significant proportion of their incomes from off-farm activities such as skilled labor, petty commerce, and migration.

Modeling results

Downscaled projections from different climate models differ as to the rate of change in the study zone, yet on the whole they indicate a reduction in rainfall on the order of the one observed in the 1970s and 1980s by the 2050 time horizon. Results for temperature are more consistent and indicate an increase in maximum and minimum temperature of 2 °C to 5 °C in selected months. The increase is consistently stronger in the North and for 2050.

Modeling the impact of these climatic changes on crop performance suggests that declines in yields out to 2050 may be on the order of those experienced in the 1970-1990 period. As during that period, the impact can be expected to be greater in the North. Modeling the impact of projected climate changes on biomass also indicates that the impact on available pasture will be most dramatic in the North. The limited modeling conducted for this assessment indicates that, in the North, climate change will constrain the growth of rangeland vegetation more than it will constrain the growth of crops.

Livelihood sensitivity to climate

Use of these model results to evaluate household sensitivity to climate variability and change indicates that, despite the higher proportions of more hardy crops and animals, all households in the North are significantly more sensitive to climate than those in the South. The climate in the North is so challenging that the portfolio management strategies employed — shifts to better adapted types of crops and livestock — are not sufficient to reduce sensitivity to the level found in the South. Further, the composition of household agricultural portfolios impacts sensitivity more strongly in the North. Here, livestock-dependent households are significantly more sensitive to climate than mixed system and crop-dependent households are. In the South, where differences in sensitivity are less great, crop-dependent households are the least sensitive. Across the study zone, differences in non-agricultural income sources do little to affect relative sensitivity. The probable explanation is that crop-dependent households' more

frequent engagement in off-farm income sources offsets the greater importance of remittances in livestock-dependent households.

Livelihood system adaptive capacity

Differences in the level of household dependence on crop farming and livestock raising correlate with levels of adaptive capacity, as measured by the assets households own, control, or access. Households in the North with mixed crop/livestock systems prove to be the wealthiest, followed by households in the South that depend primarily on livestock raising. Crop-dependent households in the South are poorest. Analysis of livelihood stresses mirrors these results.

The increased importance of capital in livestock raising over the past several decades, reported in focus group discussions, helps to explain this pattern. In the North, where agricultural risk is greatest, households with access to cash spread their risk across the two systems — crop farming and livestock raising. In the South, where risk is less significant, wealthier households invest more heavily in livestock; conversely, poorer households are unable to invest in livestock.

Vulnerability to climate change

Analysis based on the exposure, sensitivity, and adaptive capacity of the three different livelihood types finds noteworthy differences in climate change vulnerability. Overall, livestock-dependent households in the North are the most vulnerable, while livestock-dependent households in the South are the least vulnerable. Between these two extremes lie the households that are less dependent on livestock, the crop-dominant and mixed system households. The households of these two types have relatively similar levels of vulnerability. Further, their geography does not significantly affect their overall vulnerability. This is because although they have higher exposure and sensitivity in the North, they also have higher levels of adaptive capacity in the North. In the South, where exposure and sensitivity are lower, adaptive capacity is also lower. Results based on potential changes in climate at the 2030 or 2050 horizons do not differ substantially from these findings.

With regard to the assessment hypothesis, the quantified results presented in this assessment lead to the conclusion that livestock dominated households in both the North and the South are more exposed and sensitive to climate change than households of other livelihood types. Nevertheless, while holding livestock may not itself be the cause, the hypothesis appears true in the southern portion of the study zone. Although the pasture they rely on has been, and is likely to continue to be, more sensitive to climate variation and change relative to crop farming in this sub-zone, households that depend on livestock have, on the whole, significantly greater resources to attenuate this vulnerability and currently experience significantly fewer signs of livelihood stress. It appears the wealthiest houses in the southern zone own and invest in livestock. From the perspective of these households, other factors may override the climate sensitivity of the pasture their animals rely on. These considerations may include the risk management advantages provided by a diversified portfolio; the household's access to sufficient pasture of good quality in diverse locations; or the storage value of livestock, absent other forms of savings or investment. Because of their wealth, in this sub-zone livestock-dependent households are less vulnerable to climate change than either mixed or crop-dependent households.

In the North, however, contrary to the hypothesis of this assessment, livestock-dependent households appear to be the most vulnerable. Climate strongly affects the quantity of available pasture with which they may feed their livestock, and the livestock dependent households in the North have fewer resources to address climatic variation relative to the mixed system households. Although this assessment was unable to model their reliance on pasture outside of the northern sub-zone, it did document trends that threaten continued access to this resource by these households. Focus group and key informant interviews, as well as land use mapping, identify the following drivers of reduced pasture in the southern zone: bush fires, agricultural expansion, exploitation of lowlands, deforestation, fencing,

and increased investment in livestock. Competition for the remaining resources has also provoked tensions that may result in conflict and further restrict access. The pasture in the southern sub-zone that mitigates their vulnerability now is likely to be less available in the future. While their adaptive capacity is similar to that of crop-dominant households, it is more dependent on migration remittances, which focus group participants report have been declining in recent decades. As with the households in the South, it is unclear whether the sensitivity of livestock raising is the cause of their relative lack of wealth, or an existing lack of wealth the cause of an absence of investment in crop agriculture.

The following chapters present caveats to these conclusions, yet it is clear that geography, climate, and the availability of pasture, influence whether the hypothesis of this assessment is correct for a particular population. It also highlights other factors that strongly influence the vulnerability of a particular household or person, such as wealth, the composition of agricultural portfolios, non-agricultural sources of income, and gender.

The external context outside these communities also plays a role in the vulnerability of livelihoods. Markets and the efforts of governmental institutions, projects, and civil society certainly will affect the vulnerability pathways of the different livelihoods in this area of Senegal. As climate change makes production and prices less reliable, it will decrease the effectiveness of market engagement as a livelihood strategy. Given the storage and mobility inherent to the current system of livestock raising, these deteriorating conditions may affect livestock holders less than they will affect households that rely more on crop farming. However, when extreme drought hits, livestock holders, unlike farmers, will face the choice between losing their productive capital altogether or selling it at low prices in saturated markets.

As to institutions, key informant interviews found no significant differences in readiness to support climate adaptation by households of the three types of livelihoods studied. Literature does, however, indicate a lack of the following: state-supported means for transhumant and semi-transhumant herders to gain pasture and water point tenure; national livestock policy and programs promoting the intensification of livestock production and its integration into agricultural systems; and clear national policy and programs supporting commercial agriculture.

Options for supporting climate change adaptation

The options for reducing climate change vulnerability in the study zone recommended by this assessment will have to be implemented in a region of Senegal beset by a host of non-climate stressors. The households of Eastern Senegal face enormous challenges to improving their condition. Rural producers work in an area virtually void of public infrastructure. Markets are hard to access, and they function poorly. Local governments receive limited support from the national government and are poorly understood and under-resourced. The natural resources on hand to overcome these constraints consist of limited lands, depleted soils, disappearing forests, and an increasingly severe climate. These conditions, combined with a growing population, mean that, even absent climate change, the government and its partners face an overwhelming number of challenges in supporting these communities. Because farmers and herders integrate their adaptive responses into larger household and community strategies, support across a range of sectors — agriculture, local government capacity, transportation, or even health or education — will reduce the climate vulnerability of these communities if successfully implemented.

This assessment, however, focuses on options that more directly target climate change vulnerabilities. Possible options span diverse domains: agricultural research, extension and technical advice, local government capacity building, and infrastructure investment. Making selections among these options involves consideration of both government policies and the strategic plans of multiple donors; it requires broad consultation and concerted decision making. To begin this decision-making process, and produce

this study's recommendations, ARCC engaged in a multi-step process of presentation, discussion, validation, and prioritization. This process included a workshop to review and validate recommended options, the presentation and discussion of options with decision makers in the study zone, and the prioritization of options through a Multi-Criteria Analysis activity in a national level stakeholder workshop in Dakar. The resulting recommendations take into account the diversity of factors the assessment identified that characterize the climate change vulnerability of the agro-pastoralist households of eastern Senegal. They target the study zone as a whole, not specific household types or sub-zones of the study area, and thus allow for the dynamic nature of rural producer responses to a complex and changing context. Adapting these options to the communities, households, and individuals of the study zone will require an ongoing process of collaboration with the people on the front lines of adaptation. The list below presents, in ranked order, the options identified.

- **Raise awareness and the capacity of rural communities regarding climate change and disaster management.** The extremely low capacity of local institutions could be strengthened through efforts to increase their ability to manage information and knowledge to assess and prioritize climate risks; improve planning to strengthen flexibility and innovation in the face of climate trends and shocks; increase capacity to be responsive to evolving community needs through greater participation; and strengthen accountability and redress power imbalances.

- **Strengthen national climate and early warning information system.** The broad dissemination of timely, accurate and complete climate and early warning information underpins effective climate change adaptation and disaster management. Better access to reliable weather information and forecasting would help both herders and farmers improve their decision making regarding the "what, when and where" of managing their animals and planting their crops. It would enable both poor and wealthy households to make critical and effective low-cost adjustments to their activities.

- **Strengthen systems to increase producer access to diverse and high quality seeds.** Farmers regularly change the proportions and types of crops they plant as one of the most basic, widespread, and effective methods to adapt to climate change. Increasing farmer access to the seed they need on a sustainable basis requires improvements to the existing decentralized means of maintaining seed quality and managing distribution, such as community or commercial seed banks.

- **Promote the integration of livestock raising in crop agriculture systems.** Increasing support for poorer households to make the shift toward the integration of livestock — particularly small ruminants and poultry — into their cropping systems will be an important factor in reducing vulnerability through the diversification of climate risk. However, this option must be implemented with the recognition that expanding certain forms of livestock raising will augment existing competition over livestock resources.

- **Promote small and micro irrigation.** Overcoming the feasibility challenges to improved management of surface water will become particularly important if precipitation falls in an increasingly erratic manner, and the frequency of heavy events increase as expected. Further, approaches extending cultivation to currently unfarmed lowlands may result in localized environmental impact, and reduce pasture lands.

- **Invest in research for climate-adapted crop varieties.** Improved access to improved crop varieties that address farmer needs would clearly reduce vulnerability. For the study zone, greater access to improved short cycle multi-purpose seeds that provide for both food and forage would benefit farmers and herders. In Senegal, long-term planning, political will, and

significant long-term funding are required to improve research on new crops. The institutional and human capacity constraints of the extension process also must also be overcome.

- **Promote market gardening and production of niche crops, such as bee keeping.** This approach to diversifying agricultural livelihoods in a way that is frequently managed by women for their benefit currently receives significant support, with the USAID-funded Yaajeende project but one of many examples. In addition to production challenges, implementing this option also requires addressing constraints to marketing produce in the study zone.
- **Promote field practices to strengthen the management of runoff water.** Fewer farmers employ field management practices such as *demi-lunes, zai* (planting pits), and bunds in Senegal than in other countries of the Sahel. Climate change is nevertheless likely to make the management of runoff increasingly important to crop yields. Where farmers have stable and recognized rights to the land, the adoption of such practices pose fewer resource tenure issues than improved management of common resources, such as pasture.
- **Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest.** Successful implementation of this option will require mounting a sustained effort across multiple sectors and institutional levels to improve resource tenure. However, if successful, this approach will help manage local tensions that might otherwise be expected to increase in the study zone. It should also improve resilience and productivity.
- **Promote techniques to increase fodder production and collection.** Introducing high-yield forage varieties and improving systems for the storage and sale of forage would help ease the twin burden of feed and mobility for livestock owners, problems that this assessment projects will increase in the coming years.
- **Reinforce veterinary services.** The households of the study zone have greater access to veterinarians than other sources of aid from outside their communities. The demand for improved livestock health will increase if households in the Southern zone of the assessment continue the trend of investing in livestock as a means to diversify their agricultural systems.
- **Clarify tenure rights in livestock corridors and pasture.** While this option would attenuate the growing tensions regarding pasture and would help manage potential conflict and improve resilience and productivity, it would require substantial capacity building of local governance institutions. However, extensive experience outside of the study zone exists to draw upon.
- **Establish instruments for crop and livestock insurance.** Although such insurance accurately targets climate-based risk, implementation challenges will need to be resolved before it can be widely promoted.

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

In May 2012, USAID/Senegal began discussions with USAID/Washington and the ARCC program team to plan a Climate Change Vulnerability Assessment and Options Analysis to inform USAID Mission programming in Senegal. In September of 2012 the ARCC team began document collection and review. During the first three weeks of October, ARCC and USAID/Washington staff conducted a scoping mission in Dakar to clarify USAID/Senegal needs; complement desktop efforts with in-person meetings to identify relevant recent and ongoing research and project activities; identify potential local partners and begin discussions with them; and agree upon initial parameters of the assessment and options analysis process.

ARCC and USAID/Washington staff, in consultation with USAID/Senegal, the Government of Senegal, and other interested parties, decided that, in order to produce an in-depth assessment, the study would target a limited geographic area and focus on only one sector. Of the various regions under consideration, Eastern Senegal was selected to be studied. This area was selected due to its high level of food insecurity, as well as because it was a current — and potential future — target of USAID investment. Further, the initial scoping missions suggested that few, if any, projects that specifically focused on climate change had been previously implemented in this area. Much of the selected area also falls in the Sahel, potentially making the study applicable in an area broader than Senegal alone.

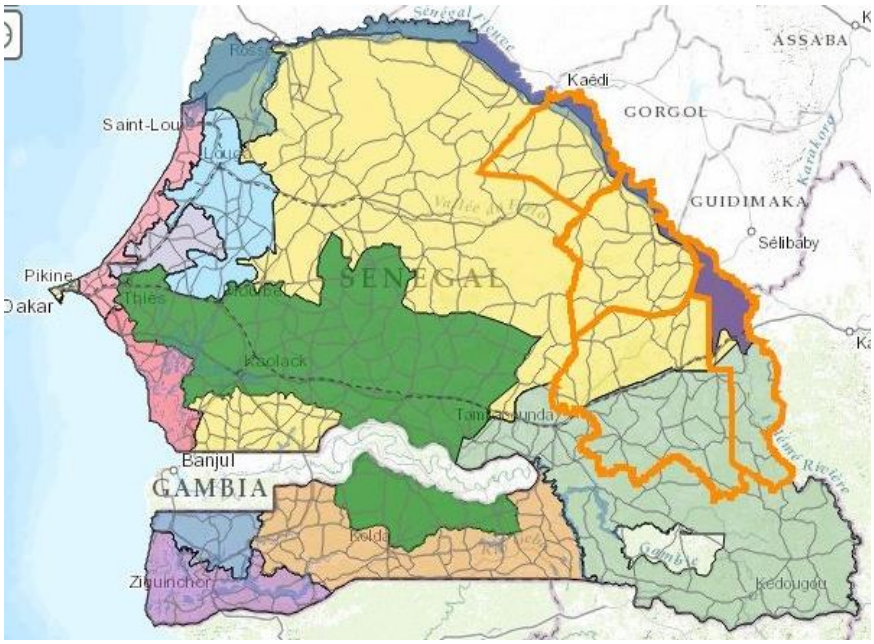
The team and the Mission agreed that the vulnerability assessment would identify current and future climate stresses in eastern Senegal, describe the potential impacts of those stresses, and assess local capacity to respond.

1.2 BRIEF OVERVIEW OF THE STUDY ZONE

The recent United Nations World Food Programme (WFP) study of vulnerability, food security, and nutrition in Senegal (WFP, 2010) provides an outline of the general vulnerability of this assessment's study area. All of the departments in the study zone have high levels of impoverishment, and more than 50 percent of households in the regions of Matam and Tambacounda, in which the study took place, are classified in the "most impoverished" category in Senegal. The departments of the study zone also have some of the highest prevalence of chronic malnutrition among children.

Sensitivity to climate variability and change and limited capacity to adapt contribute to this vulnerability. As shown in Map 1, the study area straddles two basic livelihood zones, as defined and labeled by Famine Early Warning Systems Network (FEWS NET): the sylvo-pastoral zone and the agro-sylvo-pastoral food crop zone. Despite the proven resilience of the livestock and cropping systems in eastern Senegal, productivity in the study zone could be severely limited by climate change during coming decades.

MAP 1: ARCC SENEGAL STUDY ZONE AND LIVELIHOOD ZONES



Predictions based on past trends indicate that, if those trends continue, average annual rainfall between 2010 and 2039 will drop below 500 mm across the northern portion of the study zone, the threshold considered necessary for most crop and livestock production.[1] Also, if the current trends continue, a larger portion of the region would pass above the June–September 30 °C air temperature isotherm for the 2010 and 2039 period average, amplifying the impact of rainwater shortages and significantly increasing stress on all production systems. Additionally, drought may also strike with increasing frequency. Although little is known about the effects of climate change on the pests and diseases that afflict crops and livestock, these impacts also could be substantial. (Thornton and Cramer, 2012). Given these trends, the FEWS NET report suggests that further investment in rain-fed crop agriculture in this zone may be mal-adaptive, and that "raising yields in wetter areas may be a more viable option than extending [crop] agriculture into more marginal areas" (FEWS, 2012).

During the research design process, the study area was more precisely defined as the four departments of Matam, Kanel, Goudiry, and Bakel, excluding the area between National Route 2 and the Senegal River, indicated in purple in Map 1. While contiguous to the study zone, the excluded area is characterized by larger villages, irrigation, flood-recession agriculture, and extensive immigration – a set of livelihood systems that differ from the rain-fed and extensive herding systems of the study zone, and, at least *a priori,* are less sensitive to climate change. The team decided to focus on a relatively coherent set of livelihood systems likely to be most vulnerable to climate impacts.

1.3 THE ASSESSMENT TEAM

The following team carried out this assessment:

- Dr. David M. Miller – ARCC Technical Advisor for Africa/Team Leader (ACDI/VOCA)

[1] The team cites the FEWS NET report with great hesitancy. As noted elsewhere in this document, the presence of decadal variability limits the value of the application of trends to project future climate conditions in the Sahel.

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- Sylvia Trazska – ARCC Climate Scientist (CIESIN)
- Sara-Katherine Coxon, Ayesha Dinshaw and Heather McGray (WRI)
- Sandra Baptista (CIESIN)
- Alfonso del Rio – Crops Research Scientist (University of Wisconsin-Madison)
- Leif Brottem – Researcher, Livestock (Consultant)
- Tim Finan – Vulnerability/Livelihoods Specialist (University of Arizona)
- Mamadou Baro – African Livelihoods Specialist (University of Arizona)
- Heni Mathieu Lo (*Institut des Sciences de l'Environnement, Université CAD of Dakar, Sénégal*)

1.4 SUB-CONTRACTS

Tetra Tech ARD subcontracted the following individuals as part of this assessment:

- Amadou M. Dieye, Technical Director at the Center for Ecological Monitoring (*Centre de Suivi Ecologique*, CSE)
- Dr. Mbaye Diop, ISRA Coordinator for the ARCC project at the Senegalese Institute for Agricultural Research (*Institut Sénégalais de Recherches Agricoles*, ISRA)

2.0 RESEARCH FRAMEWORK

Purpose: The overall purpose of the Senegal Vulnerability Assessment was to identify the various causes of vulnerability of the households in the study zone, and, of those causes, identify those for which there is potential for a viable remedy through USAID programming. The study does not propose a distinct food security strategy, but rather serves as a basis for USAID to strengthen the climate change perspective of mission food security programming and activities in the study zone.

Hypothesis: The hypothesis that drove this research tested a conclusion drawn elsewhere in Africa, that *households with livelihoods that include livestock are less vulnerable to climate change than households whose livelihoods primarily depend on crop agriculture.* This hypothesis had the potential to inform programming; if proven correct, it would strengthen the argument that donor and government programming should strongly support livestock-raising in eastern Senegal.

Principal Question: What are the most effective strategies for improving resilience of households to climate change?

Vulnerability Questions:

- In the study zone, households of which of the three production systems being studied (crop-dependent, mixed, livestock-dependent) are most vulnerable to climate change?
- How will the relative vulnerability of households depending on each of the different livelihood strategies under consideration change in the short-term and the long-term?
- What are the key factors that make households of the different livelihood strategies vulnerable?

Adaptation Options Questions:

- What adaptive strategies are available to households of the study zone, and how well will they reduce vulnerability to climate change in the short term and the long term?
- What are the institutional options for strengthening successful local adaptation?
- What are the research and extension options for strengthening local adaptation?

Discussion: Sensitivity to climate differs between livestock and crop agriculture systems. Where herds can be moved in response to resource availability, raising cattle and small ruminants has proven better adapted to arid conditions than crop agriculture. Research in West Africa has demonstrated that rural producers believe that livestock production has been less climate-sensitive than crop agriculture over the past 20 years (Mertz, et al., 2010). And research conducted in East Africa suggests that small farmer systems that mix both cropping and livestock systems may be less vulnerable in the face of future climate scenarios than systems based on crops alone (Thornton and Jones, 2009).

Despite this research, the question of whether livestock has the comparative advantage over crop agriculture in any particular location depends on a number of factors. Livestock systems can, to a greater or lesser extent, share vulnerabilities with crop systems. Often, when crops fail, livestock keepers lose access to crop residue and hay, and they suffer from the reduced availability of any local crops used as feed. In a widespread drought, livestock owners may not be able to move their herds to areas of sufficient feed and water. A herder hit by severe drought will find it more difficult to rebuild his herds in following years than a farmer will in finding seed to plant. This study explores the climate

vulnerability of three livelihood systems — crop-dependent, mixed, and livestock dependent — as they are practiced in eastern Senegal. It describes the current climatic vulnerability of the households that practice them and explores the different ways in which the direct impacts of changes in temperature, rainfall, and frequency of extreme events may increase their vulnerability along the north/south transect of the study zone.

Currently, households basing their livelihoods on livestock raising predominate much of the hot and arid regions of Senegal. If the hypothesis is correct, that would mean that, as the climate changes, the areas where livestock raising has the comparative advantage may expand south. At the same time, along the descending southern edge of this livestock zone, greater integration of livestock-raising into farming systems may increase household climate resilience.

How this work will inform USAID programming: While climate may favor extensive livestock raising, across much of Africa, socioeconomic conditions historically have worked against livestock systems. In particular, agricultural expansion has reduced rangeland, often forcing livestock holders to take up crop agriculture.[2] In recent decades, in Eastern Senegal, the spread of the peanut basin eastward has interrupted or blocked seasonal pastoral movements, resulting in a shift from a north-south trajectory of transhumant corridors oriented towards the Ferlo rangelands to a more limited path cutting east to west following the Senegal River. The present assessment raises the question of whether USAID programming should respond to climate change through investment supporting livestock raising in the study area. It also revisits the question raised by the FEWS NET trend study, that further investment in crop agriculture in the northern portion of the study zone may not be justified, as conditions will no longer support crops. And it tests the conclusion of Mertz et al. (2010) that the livestock sector should "receive top priority… [because] it is perceived to be a less climate sensitive activity."

2.1 ANALYTICAL APPROACH

The assessment of vulnerability to climate change is an evolving field, and experts continue to work to define the analytical approaches that best fit the subject. This assessment follows the definition of climate change vulnerability presented in the IPCC Fourth Assessment Report (Parry et al., 2007), which defines climate change vulnerability as a "function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." This framework has been applied to two distinct but linked components: a livelihood assessment, and a hazard-impact study. The livelihood assessment focuses on current vulnerability to climate, while the hazard-impact component focuses on how climatic change may change vulnerability. Together, these components answer the questions: Who is vulnerable? and How can future vulnerability be reduced?

2.1.1 The assessment framework

While the present assessment followed the IPCC definition of vulnerability, it adapted that framework to the purposes of this specific study, as most vulnerability assessments do. Here, the key terms exposure, sensitivity, and adaptive capacity are defined as follows:

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[2] National policy often reinforces this transition. In 2004, the Government of Senegal enacted the Agro-sylvo-pastoral Orientation Law (French acronym: LOASP), which emphasizes the importance of pastoral livestock production as an important form of land use; however, it also emphasizes market-based agriculture and land privatization, which could exacerbate resource access issues for pastoralists if competition for land increases.

Exposure: the biophysical limits imposed by climate, specifically the constraints to cropping and livestock systems produced by rainfall and temperature patterns. These parameters largely fall beyond human control and include the following:

- Cropping systems: less favorable conditions for the production of millet, sorghum, cowpea, groundnuts, and maize;
- Livestock systems: decreased quality and quantity of rangeland vegetation; decreased surface water availability, and reduced availability of field crop residue; and
- Markets: increased rates of road deterioration and rising frequency of commodity price shocks.

Sensitivity: the current relative dependence of households on climate-affected production and exchange systems. Specific indicators include:

- Proportion of off-farm to on-farm income;
- Proportion of livestock to crops farmed;
- Proportion of large/small ruminants;
- Proportion of vulnerable/less vulnerable crops; and
- Level of market engagement.

CLIMATE CHANGE VULNERABILITY: DEFINITION

The IPCC (2007) defines climate change vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptive Capacity: the ability of a household to modify its circumstances or behavior so as to successfully adjust to existing and anticipated external climate trends and shocks. Central to this ability is household access to or control over assets, here grouped into the five forms of capital of the sustainable livelihood framework, with examples:

- Human: health, nutrition, labor, education
- Natural: fields, pasture, water
- Physical: property, farm machinery and tools
- Social: farmers' associations, kinship networks, extension services, development programs
- Financial: income (including remittances, seasonal migration, crop sales, paid employment), stored wealth/assets

A household's capacity to respond to adversity is also shaped by the non-climatic stressors it faces — immediate constraints to employing the assets listed above. These stressors can include chronic illness, food insecurity, and loss of access to productive resources. This assessment uses these indicators of general vulnerability and declining conditions for production as a second set of capacity indicators. Some of them are similar to indicators of "sensitivity" used in other climate change vulnerability assessments (see, for example, Hahn, 2009); however, here they are used to provide a second perspective on adaptive capacity.

The assessment also considers the role of institutions external to the community in supporting or facilitating households in their efforts to adapt to climate change. These institutions include markets, local government, development projects, and the government's technical services.

2.1.2 Livelihood vulnerability assessment

The livelihood assessment, based largely on a household survey, is used to create a description of the current status of households in the study zone. This perspective ("who is vulnerable now") is important because, in an economy dominated by agriculture, it indicates who will be most vulnerable to climate variability and extremes in the short term. It also provides a foundation, a baseline, for understanding the potential future impact of climate change. Through an assessment of assets owned or controlled by households, it takes into account the wide range of factors — climate and non-climate — that determine current household status, and compares the relative vulnerability of households engaged in different production systems — crop dependent, mixed, and livestock dependent. It also assesses current sensitivity to climate by quantifying household income dependence on climate-impacted activities, such as crop agriculture and livestock husbandry.

A CONTEXTUAL APPROACH

As many researchers have concluded, it is effectively impossible to isolate climate factors from other sources of development, because local producers make decisions influenced by many non-climatic conditions. (Mertz et al., 2010)

2.1.3 Integrated production system hazard-impact assessment

This component uses modeling to explore the impacts of projected changes in climate on the potential productivity of different crops and livestock resources. In addition to presenting these results in isolation, they are integrated into a broader understanding of livelihoods as changes in exposure. The process provides multiple sets of descriptive data relevant to the study; it results in a novel, heuristic tool for discussing vulnerability and options for adaptation in the study zone.

2.1.4 Comparing northern and southern systems

Due to its north-south orientation, the study zone straddles different climate and agro-ecological zones. The assessment takes advantage of this fact and compares the characteristics and vulnerability of households along this transect. This comparison is used as an analogue to a possible southward shift in exposure resulting from climate change by exploring the differences in vulnerability characteristics within livelihood systems across climatic regimes.

2.1.5 Critical assumptions

Given the gaps in available literature, this research design is based on the assumptions that follow:

1. Generally in line with the different climate zones, livestock-raising plays a greater role in the livelihood strategies to the North of the study zone, and crop agriculture plays a greater role to the South (FEWS NET documents strongly suggest this is the case);
2. Differences in non-climate factors (soil, culture, surface water, forest, population) along the north/south axis of the study zone differ in ways that can be measured and accounted for in our analysis; and
3. Worst-case rainfall projections based on global climate models will present a scenario at least as significant as the FEWS NET trend projection, in which the viability of crops is no longer certain in some northern parts of the study area.

3.0 RESEARCH METHODS AND IMPLEMENTATION

The principal methods used to implement the approach described in Chapter 2 consist of fieldwork, collection and analysis of climate data and projections, crop and livestock resource modeling, spatial analysis, literature reviews, and consultation with local experts. Data for the livelihood assessment have been produced principally through key informant interviews, a survey of 450 households, and focus group fieldwork. Two modeling activities based on downscaled climate projections provided the core information for the hazard-impact assessment. Mapping has been used to represent findings and support analysis in multiple components. Literature reviews and spatial analysis have provided background on market accessibility. The understanding of adaptation options and their viability have been informed by the focus groups mentioned above, along with literature reviews on historical response to climate shocks, the institutional context, and opportunities in extension and research. Table 1 on the following page presents a summary of research components and methods. For a full discussion of the methods used in this assessment, see Annex B.

TABLE 1: SUMMARY OF PLANNED ASSESSMENT METHODS

			TEMPORAL	
		THEME	CURRENT/HISTORICAL (Who is vulnerable now?)	FUTURE (Who will become more vulnerable?)
SPATIAL	VILLAGE	Household Capacity and Sensitivity	Household Survey	Integrated Analysis
			Mapping of Survey Results with other data sets	Spatial Analysis of Survey Results with projections
		Adaptive Options	Focus Groups	Analysis of Focus Group Results
	SUPRA-LOC AL	Climate	Met Data Analysis	Downscaled Projections
		Crops	Crop Phenological Thresholds	CropWat Projections
		Livestock (Drought Management)	Herder Focus Groups	Livestock Modeling
		Livestock (Resources)	Livestock Resources (NDVI, Stats from DAPA, Dir. Hyd, Dir Elev., Soil Maps)	STEP Modeling (Sahelian Transpiration Evaporation and Production model)
		Institutions	Key Informant Interviews (Dem Capacity)	Key Informant Interviews (Awareness, Planning)
		Markets and Vulnerability	Lit Review Spatial Analysis	Road impact modeling
		Adaptation Options	Lit Review: Research/Extension Opportunities	
			Lit Review on Historical Response to Drought in Ferlo	

Note: The modeling of the livestock population response to drought was begun but not completed, and the modeling of climate impact on road networks was not conducted.

3.1 HOUSEHOLD SURVEY AND FOCUS GROUP DISCUSSIONS

3.1.1 Survey and focus group instrument design

The questionnaire

The survey instrument was designed to quantify the assets held by households, including income and assets to which households have access but do not control, such as public infrastructure and natural resources. It was organized following the five asset categories of the sustainable livelihood framework: financial, natural, human, social, and physical, with the individual questions informed by food security vulnerability surveys as well as previous ARCC climate change vulnerability assessments. Questions targeting livestock husbandry were developed following a review of similar studies. Additional questions focused on household stressors and limitations to the use of the identified assets. (Annex C presents a screenshot of the final questionnaire as completed in one household.)

The focus group discussion guide

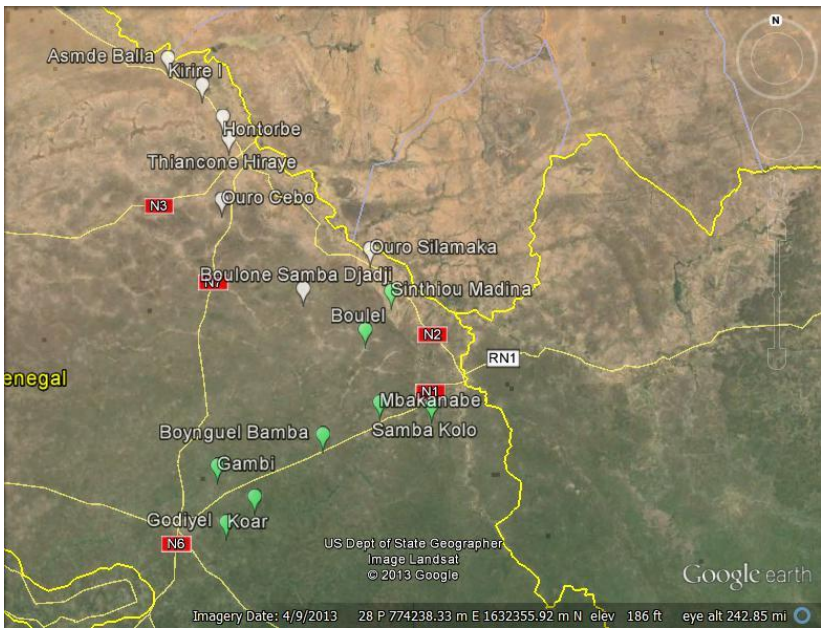
The two objectives of the focus group discussions were to provide a context for the survey results and to understand adaptive practices employed within the study area. It thus included questions concerning how people have responded to changes in the climate during the past 20 years at the household and

community level, as well as within their cropping and livestock systems. Discussion guides began with a general discussion of the village, focusing on productive activities, followed by descriptions of changes in the village during the past 20 years. The guide then addressed specific changes in farming and raising livestock. The guide's final topic discussed constraints to practicing agriculture and raising livestock. Annex D contains an example of the final focus group guide.

3.1.2 Sampling strategy: village and household

As noted above, the study focused on rural livelihoods that depend on livestock and rain-fed agriculture. As such, the population that lives along the river was not included in the study and was excluded from the sample frame. Because the study concerned vulnerable rural households, the sampling frame also excluded settlements larger than 2,000 inhabitants.

FIGURE 1: VILLAGES OF THE STUDY ZONE



To select sample villages from this frame, geographic strata reflecting populations facing different climatic conditions were created. The northern sub-zone comprises Matam and Kanel, the two most arid of the four departments studied. Bakel and Goudiry, the two most humid, constitute the southern sub-zone. These sub-zones created the two strata from which villages were are randomly selected in numbers proportional to the population of each sub-zone. See Figure 1.

Given the exclusions noted above, the total survey population was 137,908, with 65,477, or 47.4 percent living in the northern sub-zone, and 72,431 people, or 52.6 percent, in the southern sub-zone. Based on the size of these populations, as well as logistic limitations of implementing the survey, a total of 15 villages was selected. ArcGIS Sampling Design Tool was used to select seven villages from the North and eight from the South. (A complete description of the process appears in Annex E, "*Draft report on selection of survey villages.*") Because intra-village variation was expected to be greater than differences between villages, 30 households, a relatively large number in communities this small, were surveyed in each village. For villages with less than 30 households, the households in the next-nearest village were included in the sample.

3.1.3 Survey and focus group implementation

During an initial trip from October 21 to October 28, 2013, a team contacted villages to introduce the survey and set a date for its implementation. At this point, two villages were excluded because they were found to be inaccessible and were replaced by two villages previously identified for this eventuality. For more information, see Annex F, "*Rapport de mission sur la prise de contact et la prospection des villages retenus pour l'étude.*"

During the week of November 11, the ARCC assessment team trained enumerators, supervisors, and facilitators to conduct the survey and focus groups. Trainees piloted the instruments on November 16 and completed fieldwork on December 5. Two days were allotted for each of the 15 survey villages; in a number of instances the teams spent the night in the village. A total of 448 households were surveyed.

Basic information was collected in open introductory meetings with village authorities. Once the total population was defined for each location, 30 households were randomly selected from the total list. Interviews were conducted with household heads at their residence using Iform Builder software on Apple tablets. Supervisors attended interviews and reviewed results on tablets.

Separate focus groups of men and women were conducted and recorded by hand concurrently with the surveys. A total of 421 people participated in the focus group discussions, 207 of whom were men, and 214 women.

3.2 KEY INFORMANT INTERVIEWS AND ANALYSIS: THE INSTITUTIONAL CONTEXT

ARCC subcontractor World Resources Institute (WRI) undertook a review of available literature regarding institutional readiness and responses to climate variability and change in Senegal. The results were used to inform the design of the key informant interview instruments. This literature review, as well as interviews conducted during the initial scoping mission, suggested that national government efforts to address climate change have yet to have a direct impact in the study zone. For this reason, the key informant institutional interviews were conducted at the regional level and below, with staff of the institutions that have had the most direct contact with the communities of the study zone. The interviews began on November 16 and concluded on December 4. Interviewers conducted interviews at a total of 40 institutions. (See Table 2).

TABLE 2: KEY INFORMANT INTERVIEWS

	Matam	Kanel	Bakel	Goudiry	Total
Technical Service	3	2	2	1	8
Rural Council	4	3	2	5	14
Project	2	1	2	2	7
Trader	4	2	3	2	11
Total	13	8	9	10	40

To conduct the interviews, a two-person team of *Institut Sénégalais de Recherches Agricoles/Bureau d'Analyse Macro Economique* (ISRA/BAME) staff contacted key individuals at the regional, departmental, and local level (*communauté rurale*) to learn about the mandates and capacities of institutions in supporting local communities and crop-based and livestock-based production systems in the management of climate variability and change. Questions focused on demonstrated institutional capacity, awareness, and planning regarding climate events, whether perceived as natural or anthropogenic. Interview instruments were developed in collaboration with WRI and ISRA/BAME staff. Complete final questionnaires can be found in Annex G.

3.3 CLIMATE DATA AND METHODS

3.3.1 Current climate

The selection of station data used in the analysis was based on availability and proximity. Current climate and its variability in the study zone has been described using *in-situ* observations of rainfall, maximum and minimum temperature, relative humidity, insolation, and wind from five stations (Tambaconda, Bakel, Goudiry, Matam, and Bakel). ISRA analyzed and made available archives of monthly records of those variables for the period 1970-2010, as well as daily records of rainfall covering most of the period.

TABLE 3: YEARS SELECTED FOR HISTORICAL SIMULATIONS

Driest Years		Average Years		Wettest Years	
1984	1977	1987	1979	1988	1981
2002	1992	1998	1995	2003	1994

In order to reveal larger trends "hidden" in patterns that follow daily, yearly, and decadal cycles, rainfall data was pooled into two periods, one spanning from 1971 to 1990, and a second beginning in 1991 and ending in 2010. These periods were selected because they bracket two distinct rainfall periods previously observed in the Sahel, in Senegal, and in the annual data for the study zone. Annual rainfall in the first 20-year period was, on average, lower than the second. Analyses of this station data documented long-term changes in average rainfall, temperature, relative humidity, insolation, and wind. It was also used to provide context for the projections undertaken.

3.3.2 Future climate

Projections of future climatic conditions are produced using General Circulation Models (GCMs), numerical representations of physical and chemical processes in the climate system. For this assessment, projections for rainfall, maximum and minimum temperature, relative humidity, and wind speed were derived from the Coupled Model Inter-comparison Project Phase 5 (CMIP5) archive, a collection of simulations performed by leading modeling centers around the world.

While GCMs represent state-of-the-art tools, they allow only imperfect representations of the climate in any given location. To circumvent systematic errors and to provide a more realistic estimation of future climate, analysis included a statistical downscaling scheme in which relationships between historical observed and simulated values were used.

Projection data was selected from 10 models under the RCP4.5 "current level" and RCP8.5 "increased level" emission scenarios. Using observations provided by ISRA for the five weather stations, the projections were downscaled for the periods 2020 to 2040 and 2040 to 2060 to project climate conditions around the years 2030 and 2050. These projections were then evaluated in terms of average conditions as well as variability and spread among results from different models. Observed changes in climate variables between recent periods — 1971 to 1990 (drier) and 1991 to 2010 (wetter) — also provided context for evaluating the projections.

3.4 MODELING OF CLIMATE IMPACT ON CROPS

To explore current climate threats to, and potential future exposure of, households depending on specific crops, projections of the direct impacts of changing climatic conditions on crop productivity

were produced using the CropWat model (FAO, 2013). Developed by the Food and Agriculture Organization of the United Nations (FAO), this model relates crop yields to a plant's water requirements based on prevailing meteorological conditions (temperature, humidity, solar radiation, and wind); soil characteristics; crop development stages; and farming. To evaluate the sensitivity of crops to changes in the conditions of the study zone, ISRA simulated the performance of the crops using observed meteorological data for the driest, average, and wettest years for each of the two periods, the dryer 1971to 1990 and the wetter 1991 to 2010.

Similar to the historical simulations, modeling of future changes in crop production used projections of metrological data pooled into 20-year periods, one centered on 2030 (2020 to 2040) and one centered on 2050 (2040 to 2060). Given the spread of results from different models, the assessment of impacts on crops was conducted by modeling based on the driest (most pessimistic), wettest (most optimistic), and average models over the region. Because the available data is insufficient to reliably interpolate between stations, data available from two or three stations have been used to illustrate climatic conditions found in each sub-zone.

Modeling was conducted for the most widespread varieties of millet, sorghum, maize, cowpea, and groundnut. Parameters for characteristics of these varieties, such as root growth and duration of each phenological phase, were drawn from data based on local research; the FAO database filled gaps.

3.5 MODELING OF CLIMATE IMPACT ON LIVESTOCK RESOURCES

The assessment also includes a livestock modeling exercise. This study explores the impact of climate change on the natural resources upon which livestock depend in the study zone, principally pasture, water points, and crop residue, but not impacts directly on livestock, such as disease and animal health. Using the same climate data as inputs as used for crop modeling, modelers have projected changes in the carrying capacity of the project zone for the years 2030 and 2050. *Centre de Suivi Ecologique* (CSE) staff modeled the evolution of natural vegetation using the Sahelian Transpiration Evaporation and Production (STEP) model, which uses daily rainfall and temperature data and soil characteristics to simulate the main relevant processes associated with herbal functioning and soil-water dynamics in the Sahelian environment. Crop residue projections were based on the results of the crop process modeling described above. Hydrological modeling was based on the relationship between rainfall, herd size, and the dates principal water points were exhausted. This is an innovative approach that, as far as the team knows, is untested in the climate change context.

3.6 LITERATURE REVIEWS

In addition to the components described above, the assessment addressed the following topics through reviews of research literature (studies written in French contain a summary in English):

- Historical response to climate shocks in eastern Senegal (see Annex H);
- Crop phenology profiles and the potential impact of climate change on pests and diseases afflicting crops important to eastern Senegal (see Annex I);
- The potential impact of climate change on livestock diseases in eastern Senegal (based on literature and interviews and expert analysis) (see Annex J);
- The role of markets in climate change vulnerability in eastern Senegal (includes spatial analysis) (see Annex K); and
- Opportunities and barriers in research and extension in eastern Senegal (also includes expert interviews) (see Annex L).

4.0 WHO IS VULNERABLE?

4.1 EXPOSURE TO CLIMATE AND NON-CLIMATE STRESSORS

4.1.1 The study zone and its stressors

MAP 2: DEPARTMENTS OF THE STUDY ZONE

The current estimate of the 2009 population for the departments of the study zone is 740,000 (GeoHive, n.d.; estimates based on the 2002 census). Of this number, 495,000 (67 percent) reside in the northern two departments, and 246,000 (33 percent) reside in the South. This population is distributed unevenly across the study zone, with the highest concentrations in the North along the river valley and National Road 2, which parallels the river. In the northern two departments the average density is 33 inhabitants per square kilometer. Density drops to an average of 10 inhabitants per square kilometer in the more sparsely populated southern departments[3]. (See "Carte demographique" in Annex M: Additional maps of the study zone.) Much of this population is poor and in poor health. The recent WFP study of vulnerability, food security, and nutrition in Senegal (WFP, 2010) classifies more than 50 percent of the households in the regions of Matam and Tambacounda in the category of "most impoverished" in Senegal. These departments also have some of the highest prevalence of chronic malnutrition among children. The principal factors leading to this general vulnerability are described below.

NORTH AND SOUTH SUB-ZONE DESCRIPTORS*

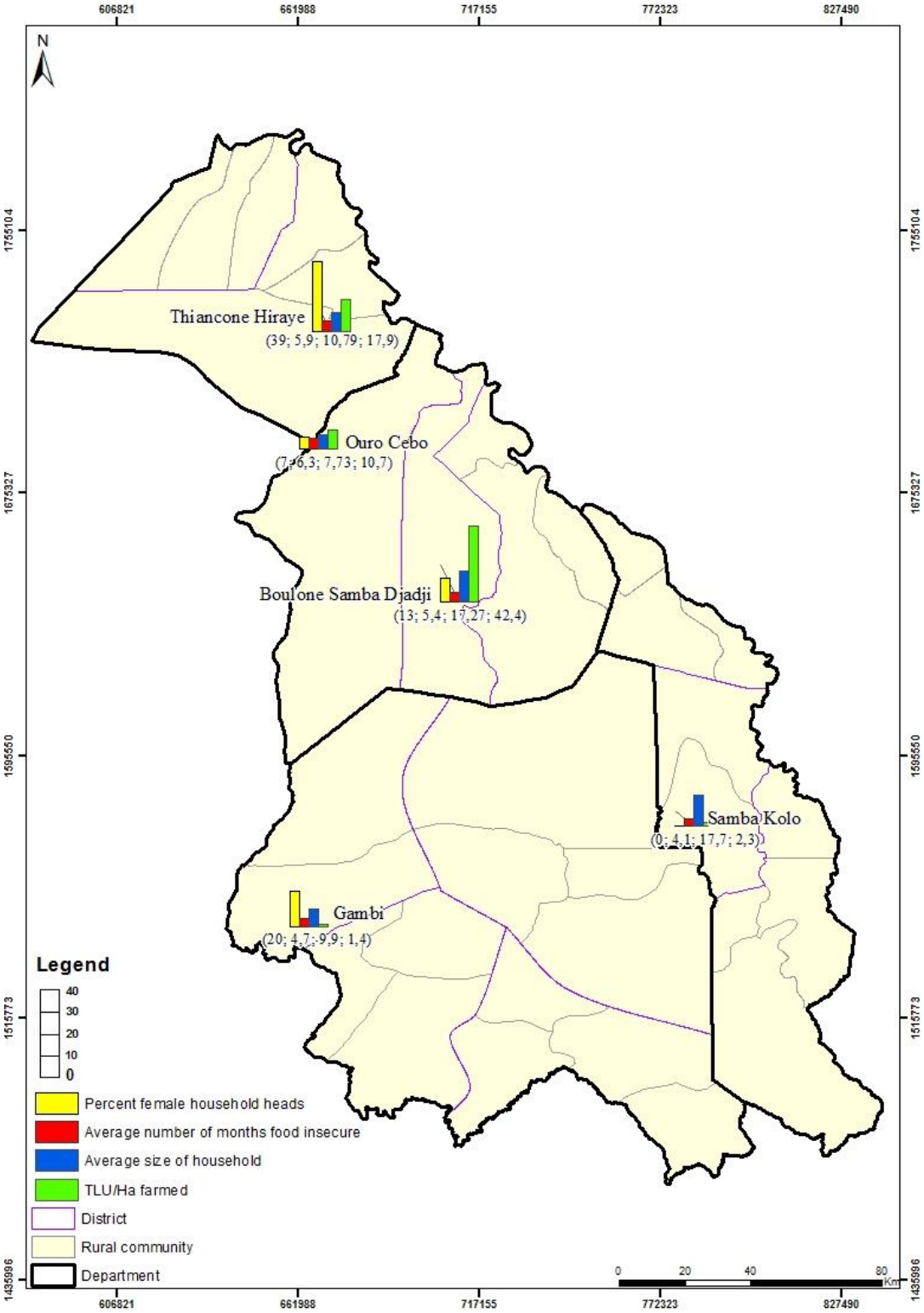
- Household (HH) size: ranges from 2 to 49 people; the average HH size is 14 people in the North and South.
- Ninety-two percent identify themselves as either Fulani or Toucouleur.
- Female HH heads: 20 percent in the North, 7 percent in the South.
- Cattle owned per HH: 18 in the North, 14 in the South.
- Sheep and goats owned per HH: 30 in the North, 13 in the South.
- Average TLU**/adult equivalent: 1.8 in the North, 0.98 in the South.
- Average hectares farmed: 5.5 in the North, 8 in the South.

**Source: ARCC household survey*

***TLU= Tropical Livestock Unit: Cattle 0.7; Sheep/Goats: 0.1*

3 This figure is based on a 2010 estimated population of 486,123 people over a surface area of 14,558 km in Matam and Kanel, and an estimated 2009 population of 232,545 people over 22,459 km in Bakel and Goudiry.

MAP 3: DIFFERENCES AMONG VILLAGES: SELECT INDICATORS, SELECT VILLAGES



Source: ARCC Senegal household survey

The population is also growing and increasing pressure on the regions' productive resources. The 2009 population estimates represent an average departmental growth of 29 percent since the 2002 census, with Matam growing the fastest at 34 percent. Along with earlier growth, this expansion is reflected in substantial changes in land use. While rainfall and shifting management of livestock may result in temporary changes in vegetative cover, between 1990 and 2008 the study zone also has seen significant long-term changes, such as an overall reduction of tree cover as well as an expansion of cropped land.

Levels of education in the zone stand out. Out of 448 households surveyed for this assessment, only one household head reported having completed secondary education. Four had completed primary education, and 15 had started but not completed primary. A much greater number, 185, had attended Koranic school. Education attainment, formal and informal, is slightly higher in the South than in the North.

Emigration plays an important role in local livelihoods across the study zone, and the influx of remittances is visible in the number of solar panels, houses constructed in cement, draft animals, and farm implements. Almost 16 percent of the households reported that emigration remittances provide over 75 percent of household income. One village identified emigration as the principal livelihood of its residents.

Matam and Kanel: The northern sub-zone falls between the Senegal River valley and the more heavily wooded zones to the South. The current estimate of the 2009 combined population of these two departments is 495,000, with 53 percent (264,000 people) in Matam and 47 percent (231,000 people) in Kanel.[4] Since at least 1990, locations with higher population concentrations, such the towns and along National Highway 2, have been associated with vegetative cover degradation. Secondary towns off of these routes, such as Sare Liou, Appe Dioube, and Yari, have seen the conversion of natural vegetation to cropland. (For a map of these and other changes in land use, see "Land Use Changes in the northern Sub-Zone" in Annex M.) This heavy loss of vegetation and the accompanying loss of wildlife was remarked upon repeatedly during focus group discussions in survey villages. Fourteen percent of the households surveyed in these two departments report farming more land now than they did 20 years ago.

TABLE 4: VARIATION WITHIN THE SAMPLE VILLAGES

	Ranges	
	North	**South**
Population	336 to 1,887	150 to 3,000
Distance from a paved road	0 to 30 km (NR2)	0 to 35 (NR1)
Distance from the river	0 to 45 km	18 to 40 km (Faleme)
Avg. TLU/Ha farmed	2.7 to 42	1.4 to 47

Note: Differences among villages of the same sub-zone can be more significant for livelihoods than the north/south differences in climate.

Two agro-ecological zones cover the relatively flat landscape of this sub-zone. Rain-fed agriculture dominates the livelihoods on *dieri,* which follows the river (but at a greater distance than the *walo* zone, which was excluded from this study). Raising livestock is more prevalent in the *Ferlo,* which covers the interior area of the region of Matam as well as much of northeastern Senegal. Cattle from this portion

[4] Ibid.

of the study zone are taken south and west to the Ranérou department of the region of Matam and various Tambacounda departments, including those being considered in this study. While the distinction between *dieri* and the *Ferlo* is not precise, roughly five of the seven survey villages of this sub-zone, all along National Route 2, are found in the former, providing a large proportion of villages practicing rain-fed agriculture in this zone otherwise dominated by either recession agriculture or extensive livestock raising. Although the communities of the northern sub-zone depend more on livestock raising than those in the southern sub-zone, of the seven villages selected for this survey, five stated that agriculture was their dominant livelihood; one selected livestock, and one selected emigration.

As to crops, literature indicates that on larger fields, families farm millet, and, in decreasing amounts, sorghum. Women also farm smaller plots (less than .5 ha) on which they grow cowpea, hibiscus, peanuts, watermelons, and various vegetables. Animal traction increasingly is used. Market access limits the opportunity for selling produce, and market gardening and the sale of cereals is found primarily along the National Route 2, which crosses the northeastern portion of this zone. Emigration also provides a significant proportion of income. Of households surveyed, 27 percent had at least one migrant among currently resident members; total migration rates can be assumed to be much higher. Focus groups identified the principal non-climatic threats to livelihoods in this zone as bush fires, insects and birds attacking crops, and animal diseases, of which pasteurellosis, botulism, and sheep pox are reportedly endemic (ANSD, 2011).

RELIANCE ON NATURAL RESOURCES

Eight percent of the households in the study zone report drawing some income from natural resource extraction, such as harvesting wild fruit or firewood. Only 4 percent report that natural resource extraction represents more than 75 percent of their household income.

Goudiry and Bakel: This portion of the study zone extends from arid zones to the forested southeastern regions of Senegal. According to the current estimate for 2009, the population of these two departments is 246,000, with 104,800 people in Goudiry (43 percent) and 141,300 (57 percent) in Bakel.[5] Since 1990, this region has seen a significant percentage of its forest areas converted to savanna grasslands, especially along the southern portion of Bakel's border with Goudiry. As significant has been the conversion of natural vegetation to cropland in a dimpled fashion covering the zone and in concentrations through the extreme north, as well as south of the city of Goudiry itself. (For a map, see "Land Use Changes in the southern Sub-Zone," in Annex M.) In focus group discussions, villagers identify wood harvesting, particularly for charcoal production by urban-based entrepreneurs, as a major factor in the dramatic degradation of forests. Decreased rainfall and increased pasturing of herds from the North are other cited factors. Almost one third of the households in the South report farming more land now than they did 20 years ago, and a fifth report not having enough land now.

As indicated in Map 1 and described in literature, the people of this sub-zone practice agro-sylvo-pastoral livelihoods similar to those of the northern sub-zone, yet the higher density of forest in the Tambacounda region results in increased dependence on forest products. Higher rainfall levels in this sub-zone, particularly in its southern portion, also result in a higher dependence on agriculture relative to livestock. The greater availability of these factors, vegetation, and rainfall, also support more sedentary livestock management practices. In interviews, surveyed village leaders indicated that agriculture is the dominant livelihood in all of the selected communities. Families farm upland rice, millet, sorghum, cowpeas, and groundnuts. Some farmers in this zone once farmed cotton but have largely

[5] Ibid.

abandoned this crop, as state support was withdrawn. Market vegetables are increasingly cultivated, particularly in lowlands and around wells. Farmers in this zone raise livestock for household meat and milk production, manure, draft power, transportation, and sale. Capital from the sale of livestock is more likely to be invested in farming here than in the North. Harvesting forest products also provides a source of income, as does artisanal gold mining. Focus groups identified the principal non-climatic threats to livelihoods in this zone as bush fires and insects and birds attacking crops. They also describe large herds of livestock from Mali and Mauritania as being a burden on local resources.

4.1.2 Gender and stressors on production in the study zone

Women find themselves bearing the consequences of both increased migration and uncertain and decreasing productivity in the study zone. As men have left to look for work elsewhere, women's responsibilities have expanded. The women who head13 percent of the households in the study zone undertake additional responsibilities. All women and girls in the study zone continue the tasks of childcare, cooking, hauling water, cleaning, and collecting wood and wild foods, while they face new challenges in production and engage in new activities such as producing and marketing vegetables. Women reported a rise in pests and diseases afflicting crops and livestock (particularly poultry), and greater scarcity and lower quality of land and forest products, including firewood. They do not migrate and do not necessarily control the use of remittances or the assets they purchase, such as animal traction or livestock. Yet, where they fill the roles of men who have migrated, their accountability in managing these resources has increased. One woman reported, "I am now both a woman and a man at the same time." Additional research would be necessary to determine the extent to which these gains in responsibility are mirrored by commensurate increases in authority in either the domestic sphere or the public domain.

TABLE 5: STUDY ZONE AVERAGE LIVESTOCK OWNED PER HOUSEHOLD BY GENDER

	Men	Women
Cattle	13	3
Sheep/goats	23	8
Poultry	4	4

4.1.3 Public institutions in the study zone and their limited influence

The external institutions with the potential to support villages in the study zone and reinforce their agricultural and livestock systems include Rural Communities (*Communautés rurales*, CR), decentralized technical services, projects, other civil society organizations, and markets. Of these, Senegal's long history of decentralization, begun in 1972, suggests that local institutions may play an important role in supporting local communities in adapting to climate change. Thus far, however, there is little evidence of them doing so. In fact, only 5 percent of households surveyed for this assessment reported having received any assistance or aid from any government institution in the past 12 months.

Rural Communities: Of the 33 Rural Communities (CR) that comprise the four departments of the study zone, Matam contains six; Kanel, five; Goudiry, 13; and Bakel, nine. The elected Council members of Rural Communities have the tasks of developing, communicating, and implementing governmental policy and programs in their districts. In executing their mandate, they work in collaboration with, and receive support from, the national government. For the group of villages in its district, a CR is the main governmental institution through which services, materials, and infrastructure are provided. The CR is responsible for ensuring the development and implementation of the five-year Local Development Plan (LDP); it coordinates a range of development tasks related to education, land management, health, natural resource management, agriculture, livestock, and infrastructure. The national government provides Council members with professional staff in the form of Community Assistants.

Decentralized Technical Services: A number of governmental institutions at the sub-national level provide support to the agricultural and livestock sectors in the departments of the study zone. These include the Regional Rural Development Directorate (*Direction Régionale du Développement Rural*, or DRDR); the Departmental Rural Development Service (*Service Départemental du Développement Rural*, or SDDR); and the Centre for Local Development (*Centre d'Appui au Développement Local*, or CADL). The state assigns these technical offices the responsibility of providing technical agricultural guidance and training. These offices also develop proposals and monitor and evaluate the implementation of agricultural policies and programs. The DRDR, SDDR, and CADL work broadly in the agricultural sector, and their mandate includes livestock and animal husbandry. To support the livestock sector, the state also provides regional inspectors and departmental veterinarians who are primarily responsible for implementing breeding programs and livestock projects. They also are responsible for the development of databases on livestock and monitoring transhumance corridors. They facilitate the establishment of farmers' organizations and play a key role in supporting the proper stabling of livestock.

Projects and Agencies: Many projects are currently being implemented in the project zone. For this assessment, interviews with the staff of five projects and one semi-autonomous state agency were conducted:

- PAPIL: The Small Local Irrigation Schemes Support Project (PAPIL), financed by the African Development Bank, began in 2006. It works in eight departments in Senegal, among them the Goudiry and Bakel departments in the Tambacounda Region. The goal of PAPIL is to reduce food insecurity through support for water management in Senegal. In the Tambacounda region, PAPIL has built a retaining reservoir, developed marshland for rice farming, reforested 350 hectares, and provided technical training and support to livestock small holders.

- ENDA LEAD: Present in the department of Bakel since 2008, the mission of this project is to build entrepreneurial capacity in rural areas of the project zone. Activities noted during key informant interviews include small-scale irrigation and small business capacity building.

- Yaajeende: NCBA/CLUSA and partners implement this five-year, USAID-funded food security initiative. The program's mission is to accelerate the participation of the very poor in rural economic growth and to improve their nutritional status. The project takes a holistic approach and supports a wide range of activities. Some of the activities discussed in the key informant interview include techniques to manage agricultural natural resources, agroforestry, training in irrigation, improving access to agricultural inputs, and market gardening.

- GRDR: The Research Action Group for Rural Development (*Groupe de Recherche et de Réalisation pour le Développement Rural)* is a French NGO created in 1969 to promote the social, cultural, and economic welfare of sub-Saharan immigrants in France and their country of origin. The NGO's activities in agriculture focus on water management, food security, and technical training. In Bakel, GRDR works in the processing of non-timber forest products, farmer/herder collaboration, developing local development plans, and fundraising.

- PROGEDE: The development objective of the Second Phase of the Sustainable and Participatory Energy Management Project for Senegal (PROGEDE) is to contribute to increasing the availability of diversified household fuels in a sustainable and gender-equitable way, and to contribute to increasing the income of participating communities while preserving the forest ecosystems.

- SAED: The semi-autonomous state agency promoting Senegal River delta and valley development (*Société nationale d'Aménagement des Terres du Delta et de la Vallée,* SAED) has been present along the river since the 1960s. SAED's mission is to improve productivity along the river valley. It develops and manages irrigation schemes and associated infrastructure along the river, and it conducts research to develop, evaluate, and support development efforts in the river valley.

- PRODAM: The assessment also conducted an interview with a beneficiary of the first phase of the Agricultural Development Project of Matam (PRODAM). The mission of this project is to strengthen agropastoral systems in the Region of Matam, in particular through the diversification of the sources of income available to vulnerable populations. Among other activities, PRODAM I invested in irrigation, roadways, agricultural credit, support for agricultural and livestock associations, and wells for livestock. The interviewed individual benefited from PRODAM support for constructing an irrigation system.

Civil society organizations: A wide array of civil society institutions engage in local development in the study zone. As intermediaries between the state and the citizens of Senegal, civil society institutions play an important role in participatory democracy and defending rights, especially those of vulnerable groups. Formally recognized NGOs have been the recipients of external assistance geared toward supporting various livelihood strategies, and they play a role in mobilizing local participation. Despite their potential, however, their reach is limited. Some 487 approved NGOs are working in Senegal, of which 184 are foreign organizations (Kamara, 2010). Of the households selected for this study, only 5 percent reported having received some sort of assistance from an NGO or project in the past 12 months. Sustainability is another major challenge for Senegal's NGOs.

As the state has relinquished its responsibilities in the process of decentralization, many people have come to rely increasingly on local farmers' associations. "Strong and active farmers' organizations are key institutions that bridge the gap between farmers, public research and extension bodies, government institutions, and international donor organizations in making agricultural technology development more effective and relevant to farmers" (Hussein, n.d.). While they are a far cry from filling the institutional space, they play an important role in managing access to natural resources. They also work to aggregate produce and facilitate the distribution of inputs and technical know-how. While ISRA reports that approximately half of the farmers in Senegal's peanut basin join associations, they do so at a much lower rate in eastern Senegal. About one-fifth of all the households of the study contain a member who recently has participated in a farmers' association; a slightly lower percentage has someone participating in a livestock producers association.

Members of the communities in the study zone also have created and maintain institutions that organize relationships within the community. They participate in age-group organizations, public work activities, and school committees. Women organize groups for both social and economic ends. Of the survey households, about one-fourth has at least one person who has recently participated in a savings group. The number is about the same for participation in sports clubs.

MAP 4: ROADS AND MARKETS OF THE STUDY ZONE

4.1.4 Markets in the study zone

Herders and farmers depend on markets to meet their need for food and other basics, as well as to generate income. The marketing system, underdeveloped at both national and study zone scales, poses limits to this strategy. As to physical infrastructure, constraints on market access include the concentration of markets along the few roads in the zone, which constrains commercial production in the moist lowlands, fields, and pastures of less densely populated areas farther off the road. Roads that do exist are in a poor state and are often impassable in the rainy season. Limited local capacity for processing, storing, and distributing farm, livestock, and dairy products also hampers commercial production. Additionally, the supply chain from rural production to urban consumption or export is informal and highly personalized, which leads to very high transaction costs. Imported low-cost, subsidized powdered milk and beef also represent a competitive challenge to the livestock sector, as does imported rice in agriculture. This lack of access to efficient markets decreases profits and dampens the conditions for commercial production by producers.

MARKET-BASED BARRIERS TO MARKETING VEGETABLES

In addition to access, numerous factors hinder farmer attempts to use markets as a livelihood strategy. Examples from vegetable marketing include:

- absence of storage facilities at markets;
- market saturation at harvest;
- limited methods to reduce spoilage in transit;
- absence of processing resources and facilities;
- little access to inputs, tools, and parts; and
- weak producer cooperative network to pool resources.

Nevertheless, markets play an important role in the economy of this agricultural zone, providing an outlet for surpluses and a source of in-demand commodities. In the study area, the markets along the river sell a significant surplus of cowpeas and livestock to buyers from outside the zone. They also import millet from the south, and maize, principally from Dakar. Away from the river in Matam and Kanel, and in the southern sub-zone of the study, markets address a net demand for cowpeas, millet, and maize. The demand for maize in the northern departments surpasses local produce by far. Across all four departments, locally produced rice is significantly overshadowed by rice imported from further down the river and from other countries. (See Annex M for FEWS NET Market Flow Maps.) Through these markets local producers also sell other goods, such as non-timber forest products (gum Arabic and fruit of the baobab, jujube [*ziziphus mauritiana*], soump [*balanites aegyptiaca*]), and dairy products, just as they purchase other goods of importance to local households, such as oil, sugar, tea, and electronics.

These transactions, like all commercial flow in the area, are constrained by the location and quality of roads that influence the presence and size of markets in the study zone. National Roads 1, 2, 3, and 7 are the only paved roads that pass through the area. NR2 follows the river to Saint-Louis and Dakar, while NR3 cuts east across the country, providing a more direct path to the capital. NR1 links the department of Bakel to the regional capital of Tambacounda and points east and is the only paved road in the southern sub-zone. The extremely poor condition of NR7, the most direct route from Matam to Tambacounda, limits its use (see Map 4). Although each segment of this road network needs repair, the relevant ministry (the *Ministère de la Coopération Internationale, des Transports Aériens, des Infrastructures et de l'Energie*) lacks funds to maintain it. The secondary roads, composed of laterite and/or sand, present an even greater constraint on the free flow of traffic than the national roads. The quality of the network as a whole reaches a low point after the rainy season creates potholes, cracks,

ruts, and washouts on blacktop surfaces. Dirt roads wash away or are flooded with river, marsh, or pond water.[6]

Along this network of roads, commodities are transported to three types of markets: permanent daily, semi-permanent, and weekly. Each of these types serves as a point to purchase local produce and resell goods from elsewhere. A seasonal pattern dominates these exchanges. After harvest, markets serve for the purchase of local produce, and for selling imported and manufactured products. During the "lean" season prior to harvest, they address local needs for food, principally cereals.

TABLE 6: MARKETS OF THE STUDY ZONE

	Permanent	Weekly or semi-Permanent
Matam Department	3	7
Kanel	4	3
Matam Region	5	0
Bakel	8	4
Goudiry	3	1
Tambacounda	3	1

The permanent Ourosougi market in the Matam Department is a national-scale hub for the sale of livestock and the purchase of cereals. Much of the goods destined for the other markets of the region pass through the Ourosougi market. Eleven other permanent markets serve the northern two departments, five of which fall in urban communes. Ten markets in these departments alternate between a weekly and a permanent status depending on the season. In the South, the department of Bakel benefits from its location on National Route 2, bordering the frontiers of Mali and Mauritania; distance from major roads limits access to the four markets in the less populated department of Goudiry. There is one weekly and three permanent urban commune markets that serve this sub-zone. (For greater detail on the markets of the study zone, see Annex N and Annex K: ISRA study on markets and vulnerability; and CSE spatial analysis of market access in the study zone.)

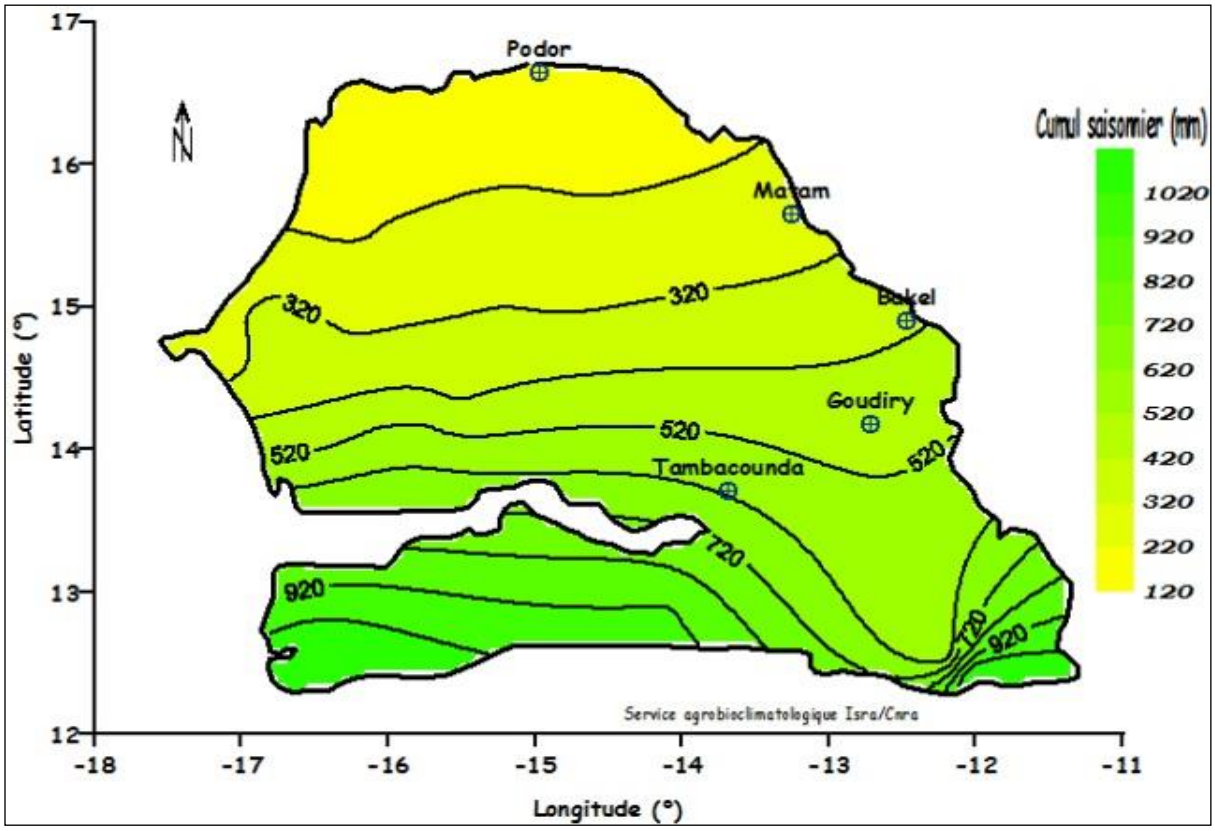
[6] While the Dakar-Niger Railway crosses the southern portion of the study zone, only direct Dakar-Bamako transportation is operational for freight, and passenger service is not provided to or from the study zone. (Booz Allen Hamilton, 2010).

4.1.5 Climate of Senegal and the study zone

Average rainfall and temperatures

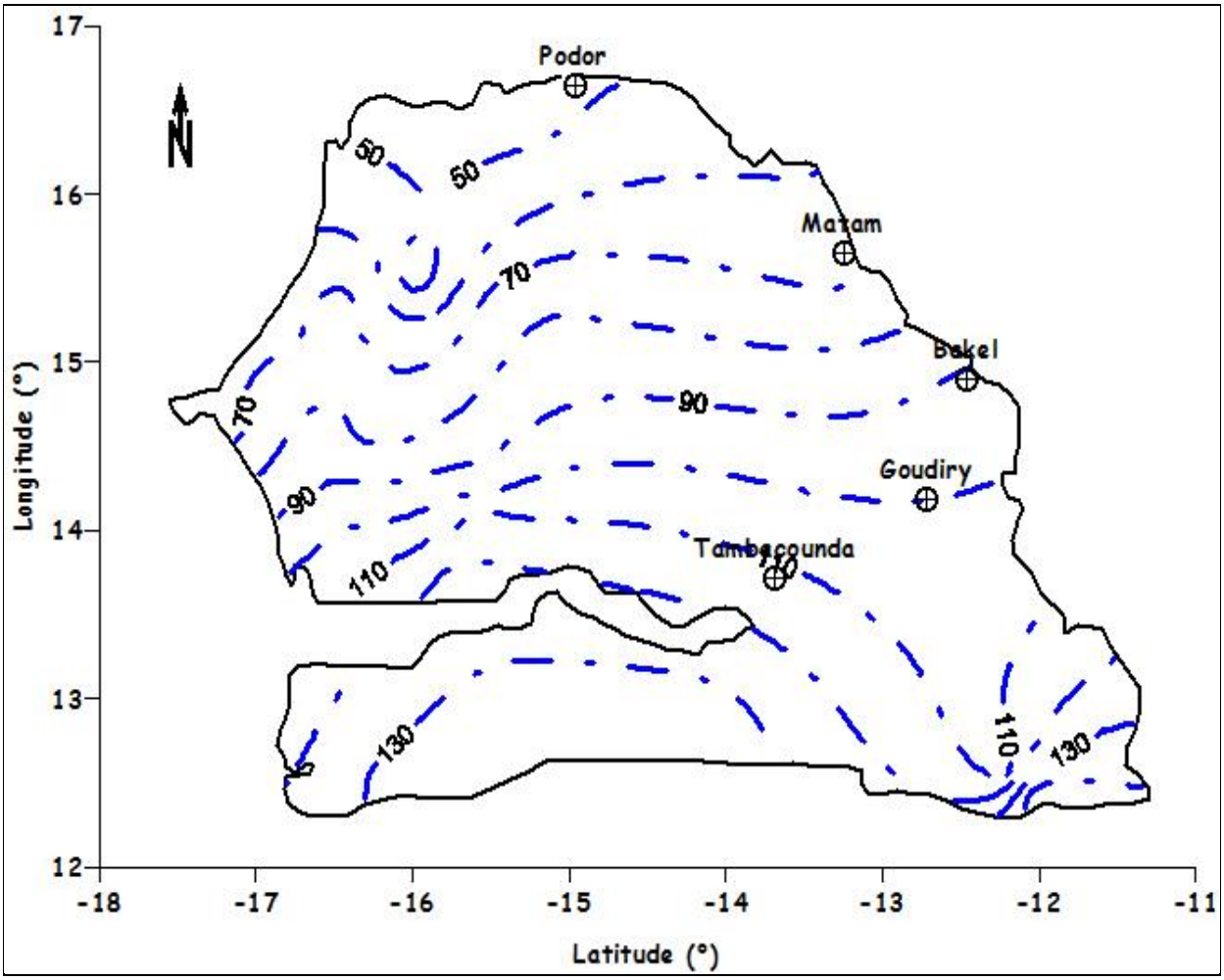
Senegal lies within the Sahelian climate, characterized by one rainy season and monthly average temperatures ranging from approximately 17 to 42 °C. The following figures summarize the main climatic characteristics of Senegal in terms of average annual total rainfall, length of rainy season, and average temperature.

FIGURE 2: SPATIAL DISTRIBUTION OF ANNUAL RAINFALL TOTAL (IN MM/YEAR)



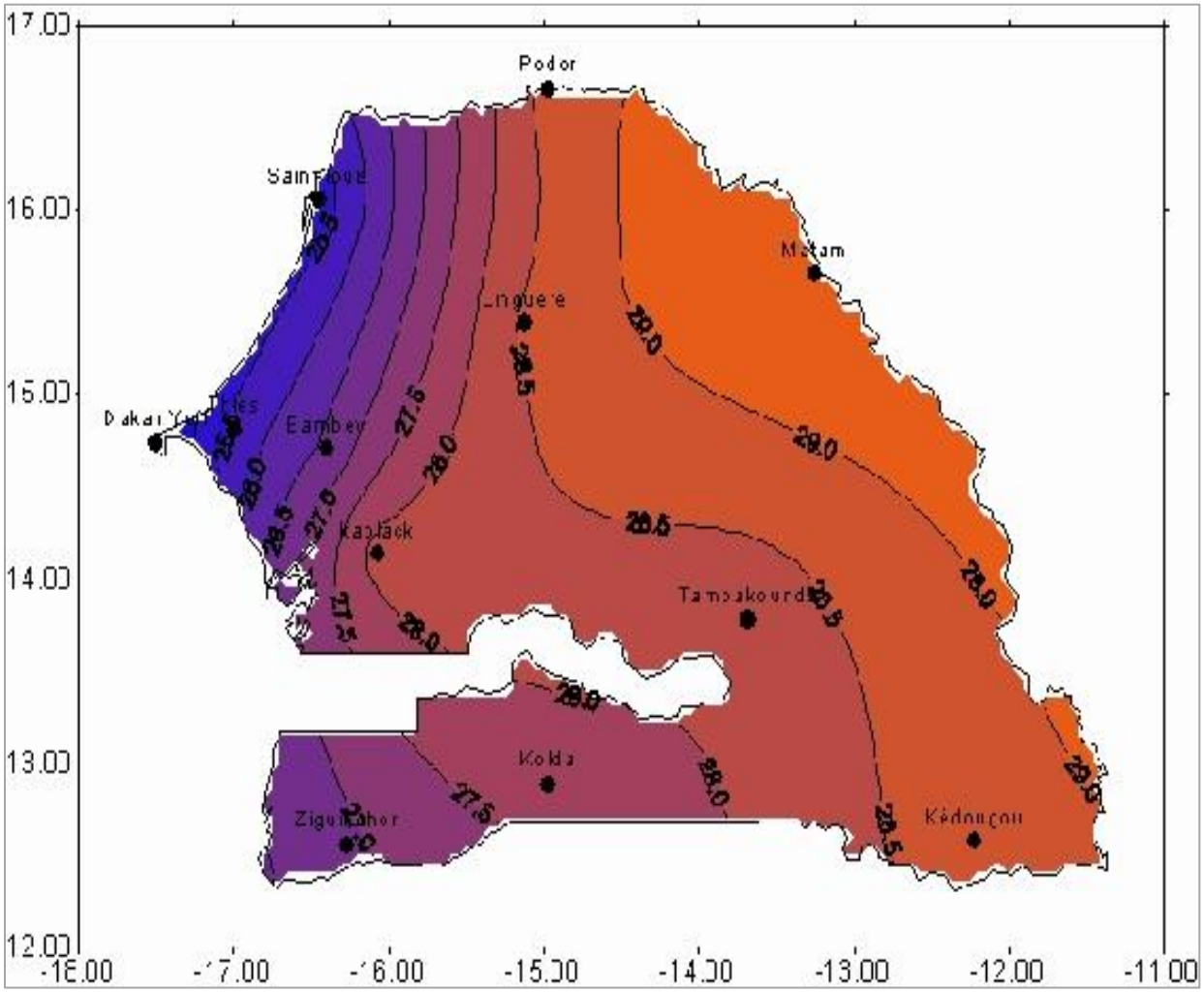
Source: Service agrobioclimatologique Isra/Cnra

FIGURE 3: LENGTH OF GROWING SEASON (IN DAYS)



Source: Sarr, 2013

FIGURE 4: AVERAGE ANNUAL TEMPERATURE (IN ^{0}C)



Source: IAO, n.d.

TABLE 7: MAIN CLIMATIC CHARACTERISTICS FOR THE STATIONS WITHIN AND ADJACENT TO THE STUDY ZONE

Station	1991-2010							1971-1990			
	Rainfall Annual total (mm/yr)	Rainfall STD inter annual	Rainfall CV inter annual	Length rainy season (days)	Probability of DS >10 days in July	Tmin Annual average (°C)	Tmax Annual average (°C)	Rainfall Annual total (mm/yr)	Relative rainfall Δ	Tmin Δ (°C)	Tmax Δ (°C)
Podor	228	74	33%	45	86%	22.0	37.0	193	-15%	-0.3	-0.5
Matam	391	132	34%	63	57%	22.8	38.0	315	-19%*	0	-0.4
Bakel	570	134	23%	76	45%	NA	NA	463	-19%*	NA	NA
Goudiry	612	114	19%	100	43%	NA	NA	609	-0.5%	NA	NA
Tamba	722	722	29%	106	17%	22.3	36.4	709	-2%	-0.2	-0.9

STD = standard deviation. CV = coefficient of variation. DS = dry spell. In the 1971–1990 period, Relative rainfall Δ = relative change in average annual rainfall with respect to 1991–2010 period; a star indicates that the change is statistically significant at p=0.05.Tmax = maximum temperature. Tmin = minimum temperature. Negative temperature anomalies indicate that the 1971–1990 period was drier and cooler than the 1991–2010 period.

FROM THE HOUSEHOLD SURVEY: CLIMATE EXTREMES

Household perceptions regarding flooding and drought indicate that climate variability is more disruptive in the North than in the South. Households in the North report a higher frequency of both flooding and drought than in the south. Years with drought in the past decade averaged 2.9 in the North, and 2.4 in the South. Years with flooding averaged .52 in the North, and .21 in the South. All villages reporting more than three years with drought are in the North; all the villages reporting fewer than one flood in the past decade are in the South.

In addition to rainfall amounts consistently decreasing from more than 900mm/year in the South to fewer than 200mm/year in the North, the length of the rainy season also decreases dramatically, from more than 130 days in the South to fewer than 50 days in the North, seriously limiting the diversity of crops that can be grown in the northern parts of the country. In addition to this north-south rainfall gradient, temperature increases from west to east as one gets away from the Atlantic Ocean and its tempering influences. Temperatures are coldest during the winter (November to January) and warmest in April–May, before cooling during the rainy season, centered on July–September.

The study zone spans a wide range of rainfall conditions roughly lying between 700 and 400 mm of rainfall per year. It is located in the eastern part of Senegal, and thus is warmer than the rest of the country. Further assessment of climatic conditions in the region was made based on *in-situ* temperature and rainfall records in Matam and Kanel for the northern zone and Bakel and Goudiry for the southern sub-zone. The analysis of daily rainfall records showed that, in addition to the total overall shorter duration of the rainy season, the occurrence of rainfall pauses — or dry spells — that may adversely affect crop growth is higher in the northern than in the southern zones. For example, the probability of a dry spell lasting more than 10 days exceeds 40 percent in July and September in Matam and Kanel but is only around 20 percent in Bakel and Goudiry. This probability is lower in August, when rainfall seems to be more regular.

FROM THE FOCUS GROUPS

Villagers across the study zone report that the climate has become increasingly erratic and less predictable. While trends are hard to identify, they do note:

- Shorter rainy periods with less total rainfall;
- Increased frequency of dry spells and downpours;
- Higher temperatures, shorter cold periods; and
- Stronger winds.

Climate variability In addition to strong spatial variations of climate and especially rainfall, the region undergoes strong variations in climatic conditions from year to year as well as on longer time scales. For example, the period from 1950 to 1969 was generally much wetter than the two decades that followed, which included multi-year droughts in the early 1970s and a regional drought in the1983 to1984 period. Since the mid-1990s, rainfall levels seem higher, although they have not recovered their pre-1970 abundance. During the period from 1991 to 2010, which has been used in this assessment as the reference period for all climate analysis, the coefficient of variation[7] of annual rainfall exceeded 30 percent in the northern zone

[7] The coefficient of variation is defined as one standard deviation divided by the average. For a normal distribution (the long-term annual rainfall distribution is close to normal), 66 percent of the values lie within ±1 standard deviation from the

and approximately 20 percent in the southern zone. The comparison between the wetter 1991–2010 and the drier 1971–1990 periods also shows that the long-term average in the 1970s–1980s was lower by 70 to 90mm in the northern zone and was statistically significant, while it was lower only by 10mm in the southern zone and statistically not significant. The already drier northern zone was even drier in the 1970s–1980s.

The interannual variations in temperature are much more limited and range between 0.5 and 0.8 °C in different stations. Despite slightly better rainfall conditions in recent decades, minimum and maximum temperatures have shown a relatively consistent increase across the stations, especially during the dry season in winter.

Interannual and decadal climate variability in Senegal, and in the Sahel in general, have been linked to naturally occurring variations in sea-surface temperatures of adjacent oceanic regions, as well as to more remote oceanic regions. Thus, interannual and decadal rainfall fluctuations may superimpose long-term climate changes related to anthropogenic influences and increase, or temporarily buffer, their effects. The increase in temperature, on the other hand, especially during the dry season, could be more directly associated with the increase in global temperature; however, the trends described above should be corrected for the effects of changes in rainfall and associated weather patterns. In any case, in all evaluations of projected climate changes, including those presented in this assessment, it is important to locate them within the context of observed climate variations and changes.

TABLE 8: RELATIVE CROP VULNERABILITY

	Relative Crop Vulnerability	
Crop	**North sub-zone**	**South sub-zone**
Cowpea	2	1
Fonio	2	1
Sorghum	2	2
Pearl Millet	3	2
Maize	4	3
Groundnut	5	5

Note: 5 = most vulnerable; 1 = least vulnerable

average, meaning that about 17 percent of the values are still above and below this limit. In our case, it means that in approximately one year out of six, the annual rainfall in the northern zone was below 70 percent of the long-term average represented on the map; in the southern zone, it was below 80 percent of the average presented on the map.

TABLE 9: AVERAGE ANNUAL RAINFALL AND TEMPERATURE: OPTIMAL AND "ABSOLUTE" LIMITS FOR FIVE CROPS

	Optimal Annual Rainfall in mm		Optimal Annual Temp in ^{0}C		Notes
	Higher	Lower (min*)	Higher (max)	Lower (min)	
Cowpea	700	400 (200)	33(35)	22 (21)	High tolerance for both drought and waterlogging
Sorghum	650	450	30	26	High drought tolerance
Pearl Millet	700	400 (350)	28 (45)	20	Less drought tolerance than sorghum
Maize	700	500	30 (35)	21	Medium drought tolerance after germination
Groundnut	700	500 (400)	30 (35)	22	

Note: Min and max figures represent absolute limits to productivity, derived from research literature.

4.1.6 Stressors on cropping systems

Non-climate stressors

Senegal's gross domestic product in agriculture has been declining since the mid-1980s. This decline is attributed to poor crop productivity associated with inadequate access to affordable fertilizer and other inputs, such as high quality seed and agricultural equipment. The natural resource base upon which cultivation depends shows steady decline, as fallows are reduced and farming practices deplete soils. Other noted challenges are labor shortages during peak periods and inadequate market opportunities. Farmers lack the means to conserve their soils and manage water while fighting a constant battle with birds, insects, and other pests and diseases that attack their crops.

Climate stressors

***Research baseline*:** A review of agronomic research conducted for this assessment produced a baseline for the relative vulnerability of the principal crops of the study zone. As summarized in Table 8, the review suggests that cowpea is the least vulnerable crop, followed by sorghum and millet, then maize and groundnuts. Most of the crops farmed in this area are adapted to the high temperatures and low rainfall of their current climatic conditions. Millet, cowpea, and sorghum are known to be resilient and have good levels of drought tolerance. Groundnut less so, yet its cultivation continues to spread across Senegal, both because farmers clear new fields as this crop "wears out" the soils in which it is cultivated, and because it is the country's most important cash crop. Nevertheless, research literature suggests that dryer-hotter conditions in Senegal will limit the areas for further groundnut expansion. The combination of heat and drought in parts of the country already has proven to affect the crop quite seriously. As indicated in a second table summarizing research literature, Table 9, the profile for maize suggests similar vulnerability to changes in rainfall and temperature.

Comparing these parameters with the climate data in Table 7 above, we see that average annual rainfall in Podor (north of the study zone) and Matam fall lower than the optimal growth range for cowpea (400mm), sorghum (450mm), millet (400mm), maize (500mm), and groundnut (500mm). One can assume that for many years in this period these crops, when they were planted, produced limited returns. Also note that in Bakel, rainfall during the 1971–1990 period dropped under the lower limit for maize and groundnuts.

The high frequency of rainfall extremes presents additional challenges to the farmers of these crops. A high frequency of extreme rainfall suggests a larger overall level of variability, with rain falling in an erratic pattern including more dry days and harder rain when it falls. In extreme rainfall conditions, some precipitation converts directly to run-off and becomes unavailable to crops.

TABLE 10: CROP MODELING RESULTS: RAINFALL IMPACT ON YIELD POTENTIALS, 1991–2010

		Δ dry (1992)	Δ wet (1994)	Amplitude
Millet (souna 3)	Matam	-51%	22%	73%
	Kanel	-2%	72%	74%
	Bakel	-29%	2%	31%
	Goudiry	-16%	-17%	0%
Maize Hybrid	Matam	-82%	8%	90%
	Kanel	-28%	71%	99%
	Bakel	-35%	7%	41%
	Goudiry	-20%	-18%	2%
Groundnuts (73-33 / 55-437)	Matam	-29%	11%	41%
	Kanel	-10%	23%	33%
	Bakel	-24%	1%	24%
	Goudiry	-3%	-2%	0%
Cowpeas (Ndiambour)	Matam	-41%	13%	54%
	Kanel	-14%	31%	45%
	Bakel	-26%	3%	30%
	Goudiry	-17%	-18%	-1%
Sorghum (CE-180-33)	Matam	-43%	18%	61%
	Kanel	-15%	-15%	0%
	Bakel	-24%	2%	26%
	Goudiry	-14%	-15%	0%

***Model Results*:** Crop modeling simulations conducted for this assessment produced a different, and more specific, portrait of the relationship between climate and yield potentials in the study zone. These results diverge slightly from what was suggested by the crop profiles based on a review of available research. For example, the results from research indicated that cowpea and sorghum would be distinctly less vulnerable than millet. The modeling simulations found a less distinct difference. A number of reasons explain this discrepancy. For one, tables 8 and 9 above present crop-level norms, while table 10 presents results from modeling specific varieties. Sorghum, for example, may take from 70 to 110 days to mature, and varieties of peanut planted in Senegal range from 80 to 120 days. Nor is the literature review able to reflect the interactions among rainfall, temperature, soil, and other factors in a particular season at a particular location. Because the simulations were based on actual data, they may contain anomalies. For example, in years where the seasonal rainfall was identified as generally good for the area as a whole, some locations might have experienced an important dry spell. Crops and crop simulations are also highly sensitive to the distribution of rainfall within the season, and the same annual rainfall totals can produce different yields depending on how that rain falls through the rainy season.[8]

Simulations were based on observed monthly climate data from years identified as dry, normal, or wet relative to other years in two reference periods, 1971 to 1990 and 1991 to 2010. Through them, the team sees that rainfall has significantly affected yield potential across the study zone, with impacts that vary substantially by department and crop.

Table 10 suggests that years with the lowest rainfall have the largest impact on yields in Matam, then Bakel; in those two stations, the increase in production in wet years is also limited. In Kanel, on the other hand, the simulated deficits are limited and the rise in production is larger. What this work shows most clearly is that the amplitude of variation — how much yields change from good years to bad years — is much higher in the northern two departments, resulting in a greater inherent risk in rain-fed agriculture in that zone. Deficits in bad years seem also more difficult to compensate for in good years.

While these simulations show the limitations of crops under specific rainfall regimes, they also highlight an additional challenge to farming in the study zone. For the men and women farmers of eastern Senegal, rainfall patterns make the difference between a bumper crop and catastrophe; however, these patterns are erratic and unpredictable. Farmers make critical decisions that affect the relationship between crops and moisture — such as crop and variety, field and soil type, and planting date. Yet because of the uncertainty of rainfall, the soundest decisions may be those that increase the diversification of risk through these choices as well as, increasingly, the decision to diversify livelihood risk through investment in assets outside of farming.

4.1.7 Stressors on livestock systems

Non-climate stressors

A wide variety of factors determine the vulnerability of different livestock production systems. A number of these factors cited in literature, (Thornton et al., 2006; Thornton et al., 2007; Van den Bossche and Coetzer, 2008), include:

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[8] The inconsistent results for Goudiry — the drops in expected yields in the "wet" years — provide an example in the present case. They stem from the fact that the dry and wet years selected for simulations were dry and wet across the entire study zone; for these particular years, Goudiry may have actually been closer to an average level of rainfall, while the other stations reported significantly less rainfall. This indication of the variability of precipitation across space serves to remind the reader that these results should all be viewed with respect for the high level of random behavior each of these simulations.

- The degree of dependence on the environment — pastoralist livestock depend largely on forage;
- The level of technical know-how of livestock owners — ability to respond to change;
- The level of risk averseness of livestock owners — where is the breaking point to trigger action?;
- The level of commercialization of livestock and its products and the access to finance; and
- The competence of public/private animal health services to provide effective prophylaxis.

TABLE 11: VARIETIES OF LIVESTOCK RAISED IN THE STUDY ZONE

	Matam	Kanel	Bakel	Goudiry
Cattle	Gobra; Guzera; Métis; Zebu maure; Boloro	Gobra; Diakoré (macce)	Naba; Gobra; Zebu maure; Macce; Bollari	Ndama
Sheep	Peul peul; Bali bali; Touabir; Ladoum	Peul peul	Ladoum; Touabir; Peul peul; Mouton nain	Touabir; Peul peul; Mouton
Goats	Chèvre du Sahel; Chèvre naine	Peul peul	Chèvre naine; Chèvre du Sahel; La Gouera	Chèvre naine; Maure; La Gouerra

For livestock production systems in the study zone, the greatest non-climate constraint to production is the absence of rights to pasture and water. The current land-extensive system of livestock-raising depends on access to resources across distances and climatic zones. In a governance context in which the act of putting land to productive use (most often through farming) confers state support, the displacement necessary for raising livestock results in weak tenure claims relative to farmers. Current Senegalese law does not define grazing rights. At the same time, governmental policy supports crop cultivation and fosters continued encroachment into pastoral areas.

In the South study zone, bush fires as well as deforestation limit the availability of forage. In determining herd movements, herders balance the risks of keeping livestock too far north too long; entering farmed areas too soon; moving to rangelands crowded by others; or grazing their animals near urban centers and markets. Similar constraints impede herder access to water. Fields and gardens have been installed near lowland sources, while the pumps of deep wells dug by projects and the government often break down; when they function, it can lead to overgrazing of the surrounding pasture. In focus groups conducted for this study, livestock holders expressed concerns regarding tension over resources between farmers and herders as well as local herders and herders from other countries, and expressed the desire for the government to play a greater role in helping resolve potential conflicts. (For additional discussion regarding herder decision making in the study zone and the important role that greater information can play, see Turner, 2014.)

Non-climate constraints facing smallholder pastoralists also include the market constraints discussed above, as well as lack of credit. (Herders currently take out costly loans to pay for feed supplements to get their animals through the dry season.) Lack of information on markets and distant rangelands also limits their productivity. Households receive privatized veterinary services at a greater rate than aid from government, NGOs, or projects. Nevertheless, almost 50 percent of households reported not having access to veterinary services, and 80 percent reported not having their animals vaccinated.

Climate stressors

Local climate — especially rainfall levels — affects livestock productivity in the study zone, as it does crop agriculture. As Table 12 shows, vegetation in the study zone responds dramatically to rainfall levels. The table compares locally calibrated NVDI observations of biomass observed during years of low, average, and high rainfall. Comparing differences between these years, one sees dramatic variation between the worst and best years, especially in Matam and Bakel.

Rainfall levels also have an important impact on other resources necessary to produce livestock. According to Department of Livestock records, between 2009 and 2013, the eight largest seasonal ponds in the study zone dry up between February and May, at dates that vary by up to three months. Also, as demonstrated in the previous section, rainfall affects the third most important climate-sensitive resource for raising livestock — farming, and the field residue and hay derived from crops. In this study, in the southern zone, livestock owners essentially depend on forage in fallow fields, crop residue in fields, and public forests.

TABLE 12: IMPACT OF RAINFALL ON BIOMASS (1991–2010)

	Dry (1992)	Δ %	Normal (1998)	Wet (1994)	Δ %	Wet-dry
Podor	312.1	-34%	475.2	331.8	-30%	4%
Matam	217.9	-56%	492.7	816.4	66%	121%
Bakel	942.4	-17%	1137.8	3251.6	186%	203%
Goudiry	2495.8	-10%	2779.1	3102.3	12%	22%
Tambacounda	2305.9	-2%	2357.9	3645.8	55%	57%

Small ruminants, and in particular goats, rely more on browsing than on grazing and can adapt better to changes in the rangelands than cattle can. Due to their shorter pregnancy period, they also allow for a much faster rebuilding of viable herd sizes during inter-drought intervals than do cattle or camels. If climate change results in more erratic rainfall, a decline in annual precipitation, or a greater frequency of drought in the study zone, it may increase the relative importance of browsers.

Indigenous livestock breeds in Senegal are well adapted to high temperatures. The main effect of heat stress in herbivores is reduced feed intake. In housed chicken, heat stress can reactivate latent infections and trigger major disease outbreaks. Under hotter conditions, the composition of pasture grasses and forage species changes, with consequences for the forage quality.

Climate also influences the pests and diseases that afflict livestock. Its impact on livestock disease is mediated by, and possibly less important than, other factors such as the degradation of rangelands and pastures, changes in human and livestock population, changes in herd mobility, and land-use. Nevertheless, changes in cloud cover, UV-radiation, humidity, temperature, and wind intensity all can affect the survival of pathogens in the environment (e.g., Salmonella) as well as their dispersal in infective aerosol droplets (e.g., foot-and-mouth disease, *peste des petits ruminants*, Newcastle disease). Under hot, dry conditions, when pastoralist livestock are forced to aggregate around water points and share very limited pastures, there is an increased risk of pathogen transmission from animal to animal. But the correlation between dry conditions and risk of disease transmission appears to be less clear in more sedentary livestock-keeping systems (Thomson, 1994). In the aftermath of droughts, pathogens often are

carried into new areas with returning herds. Regular and timely vaccinations, while animals are still in good body condition (fully immune-competent), can significantly reduce the negative effects of livestock crowding and migration during drought and dry periods.

Under dry conditions, the lifecycle of parasites that are transmitted via the environment (gastro-intestinal helminths, flukes) normally comes to a halt. The immediate surroundings of unprotected water points, however, can provide suitable conditions for transmission of parasites to a large number of animals passing through such a wet micro-environment in an otherwise arid area. Adequate infrastructure (protected watering points with troughs) is an effective means of eliminating such localized parasite transmission hot-spots.

DEFINITION: TROPICAL LIVESTOCK UNITS (TLU)/HA PER HH (WOMEN'S LAND INCLUDED)	
AG	< .5 TLU/Ha
MX	> .5 and < 5 TLU/Ha
LV	> 5 TLU/Ha

Positive effects of rainfall only come to bear several weeks after the onset of the rains and the return of good pasture. At the beginning of strong rains, animals coming out of a prolonged dry season or a drought are in poor body condition. In such a situation the very sudden change from hot and dry to cool and wet weather, often exacerbated by wind-chill effects, can trigger severe disease outbreaks. As extreme rainfall events become more common, livestock may be exposed to this stress scenario more frequently. (This discussion of the relationship between climate change and livestock disease draws heavily on Younan, 2013.)

4.2 SENSITIVITY: CURRENT RELATIVE DEPENDENCE OF LIVELIHOODS ON CLIMATE-SENSITIVE ACTIVITIES

4.2.1 Definition and description of the study livelihoods

As described in the presentation of the research approach above, in this assessment we define sensitivity as the relative dependence of households with different types of livelihoods on climate-affected means of production. To determine sensitivity, we have defined three types of households: those that predominantly raise livestock, those that predominantly farm crops, and those that are a mix of the two. These different types of households rely on different mixes of crops and livestock species. They also characteristically rely on different proportions of other forms of income, including migration remittances.

TABLE 13: DISTRIBUTION OF LIVELIHOODS IN STUDY ZONE

Livelihood Type	Percent of HHs in study zone
AG	36.2
MX	39.3
LV	24.6

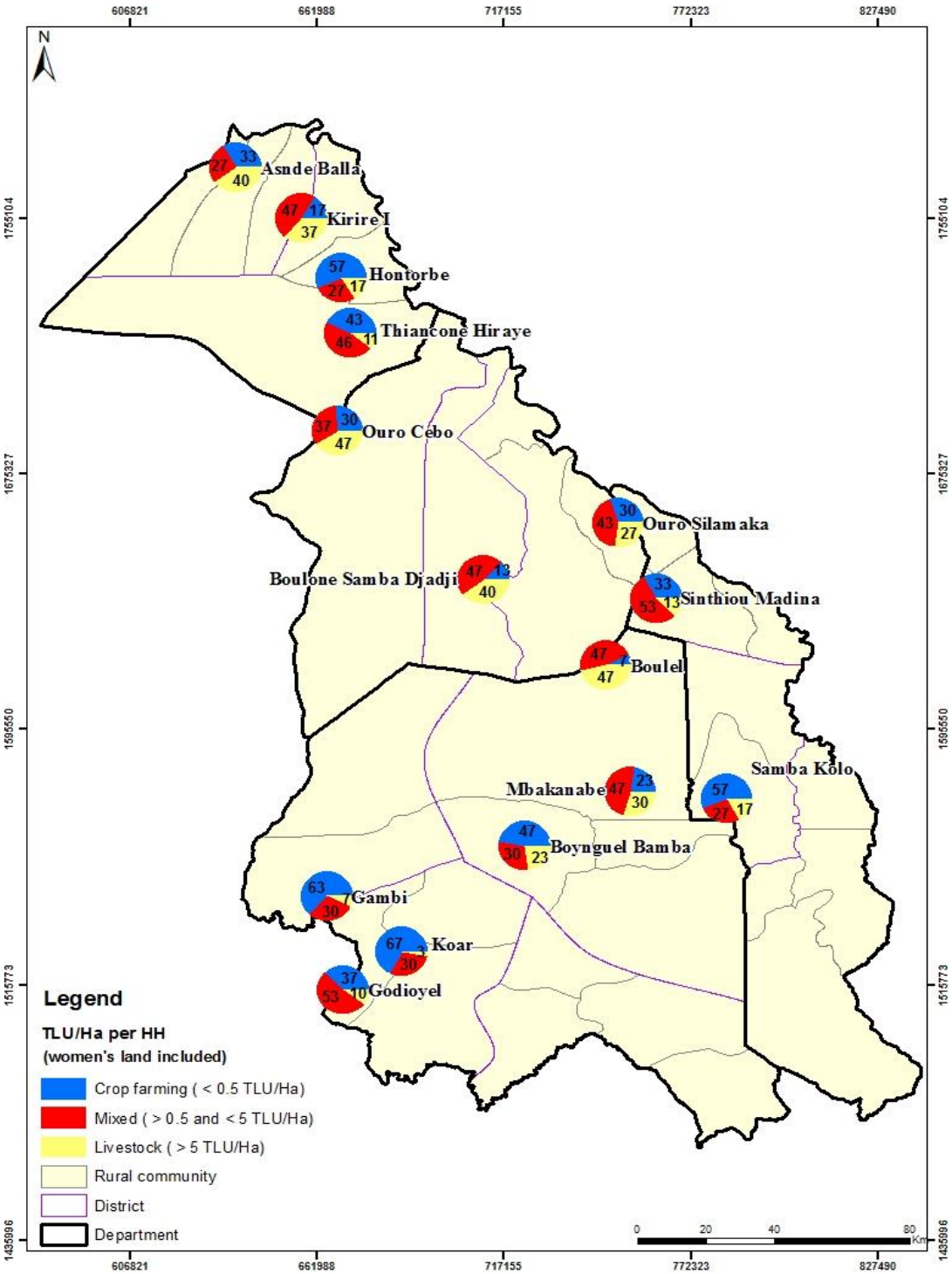
For this study, we defined livelihoods on the basis of total livestock held by the household relative to hectares of land farmed (by men and women). Livestock was calculated in terms of TLU, where cattle were weighted at 0.7 and sheep and goats at 0.1 per head. Households were classified as crop-dependent (AG) where less than .5 TLU were owned per hectare of land farmed. Households that farmed between one-half and five TLU per hectare were classified as mixed systems (MX). Households that held more than five TLU per hectare farmed were considered livestock-dependent households (LV).

After exploring other approaches to defining livelihoods, we selected this formula because the households of the three roughly equal categories it creates share other characteristics associated with that livelihood. Households defined as crop-dependent on average cultivate more land, and households

defined as livestock-dominant hold more livestock. Members of the livestock-dominant households also sent their herds on transhumance at a higher rate. This definition also sorts household types by the northern and southern subzones of the study. Villages where the plurality of households practice primarily livestock or mixed systems populate the North; only one village in this sub-zone has more households practicing primarily agriculture than the other two types. In the South, no village has a plurality of households dominated by livestock production according to this definition, and an equal number of villages have more crop-dependent and mixed households than households predominantly raising livestock. (At the same time, this definition distributes livelihoods among the villages. No category represents more than 67 percent of the households in any village, and each category is represented by at least 7 percent of the households in any village.) [9]

[9] Households with no livestock were placed in the AG category. Households with no land but with livestock were classified as LV. Of the total survey population of 448, 17 had neither farmed nor controlled land in the past year.

MAP 5: DISTRIBUTION OF LIVELIHOODS IN SURVEY VILLAGES



Other differences between the households of these livelihood types include differences in the average size of households. Households that predominantly rely on crop farming average 11 people, smaller than the average size for households of the mixed type, 15, or those that rely primarily on livestock-raising, 16 people. Crop farmers are also less likely to receive remittances from migrants. Of crop-dependent households, only 24 percent report receiving remittances. In contrast, 41 percent households that rely more on raising livestock report receiving remittances, as do 34 percent of mixed households. On the other hand, a greater percentage of households defined as crop-dependent contain members who perform skilled labor (23 percent), as compared to 15 percent for mixed systems, and 6.4 percent for livestock-dependent households. We describe these differences and others in greater detail by sub-zone in the study below.

PERVASIVENESS OF LIVESTOCK OWNERSHIP IN THE STUDY ZONE

About half of the households of the study zone own no cattle; these households are found mostly in the South. In the North, only 8 percent of the households include no male-owned sheep or goats. This number increases to 22 percent in the South.

4.2.2 Sensitivity of different livelihoods

The households of these livelihood types depend on different combinations of activities in different proportions for their subsistence and income. Some of these combinations are more sensitive to climate change variation and extremes than others. For example, a larger proportion of livestock-dependent households in the North report receiving more than 50 percent of their income from migration than other livelihood types in that sub-zone of the study. On the whole, migration plays a smaller role in household income generation in the South; but there, too, a higher proportion of livestock-dependent households receive more than 50 percent of their incomes from migration remittances. If one considers migration to be a source of income relatively un-affected by climate, this finding would suggest that they are less vulnerable to climatic variability. However, this conclusion is somewhat off-set when one looks at the allocation of household labor. A smaller proportion of livestock-dependent households engage in work away from the farm, such as skilled labor, salaried work, or petty commerce. This finding is also true for mixed-system households, but only in the South.

TABLE 14: SELECTED INDICATORS OF DEPENDENCE ON AGRICULTURE

Variable Name	Description	North			South		
		AG	MX	LV	AG	MX	LV
Substantial remittances	% HH receiving + 50% of total HH income from remittances	18	33	37	9	21	29
Off-farm labor allocation	% HH members	32	31	20	29	18	18

4.2.3 Crop portfolios by livelihood and zone

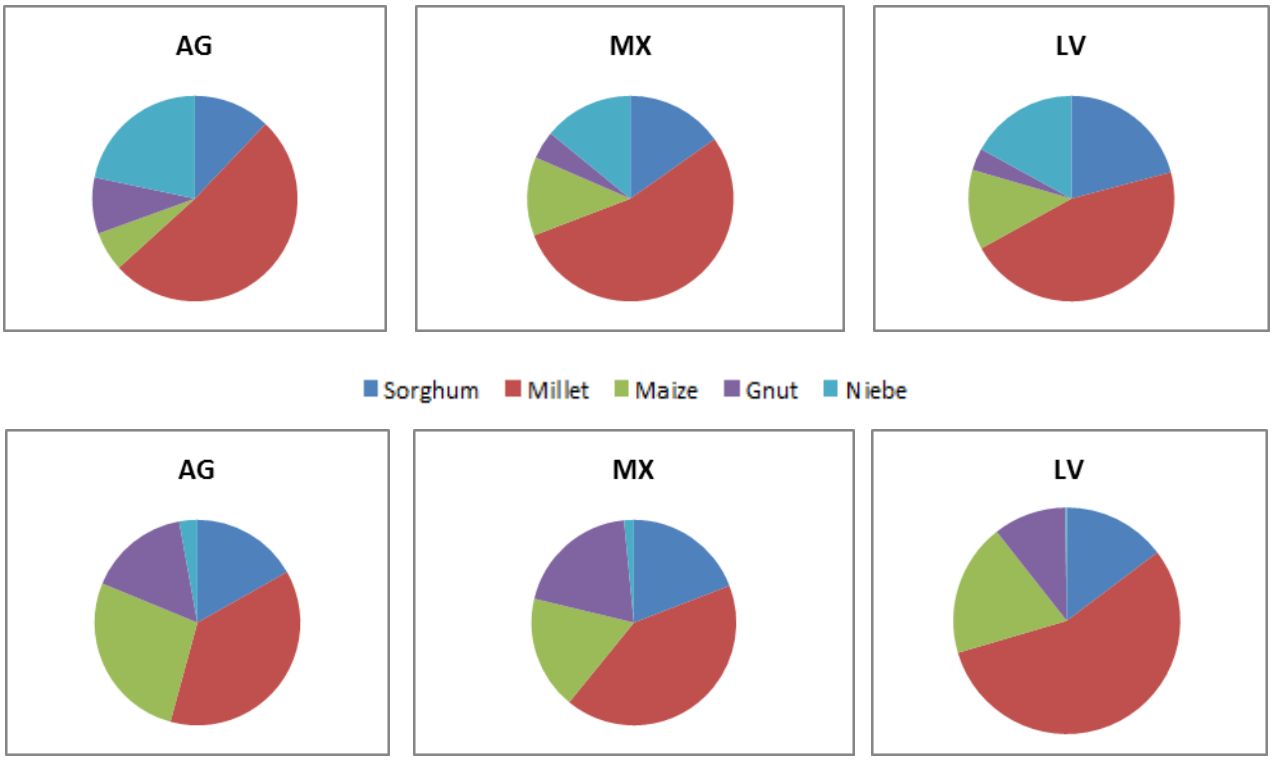
The households of the three different livelihood types cultivate crops in different proportions. The pie charts in Figures 5 and 6 present these differences for households in the North and the South and display the value of five principal crops as a proportion of the value of the total household harvest. (The sale values of vegetables and okra were included in the total household harvest but not included in the graphs.) The data for these charts was drawn from the household survey and presents reported yields from the previous year, 2012/2013, valued at the prices reported across the study zone. While annual

rainfall impacts yields, the year reported produced above-average yields for Senegal as a whole, was reported as average by focus group participants, and reasonably can be considered to have produced representative yields.

The most striking differences in these results include the greater role of groundnuts and, to a lesser extent maize, in all portfolios in the South, as well as the greater role of *niebe* (cowpeas) in the North. Millet and sorghum vary much less by geography. These differences in groundnuts and cowpeas align with our understanding of the relationship of these crops to rainfall. As described in the section on climate stressors on crops above, groundnuts are less well-adapted to the rainfall of the northern sub-zone. The government has done very little to promote groundnuts of any variety in the region of Matam. (See Annex L: ISRA Opportunities in Extension and Research, for more detail.) On the other hand, *niebe* has greater potential and represents less risk than do other crops in the North. Research identifies it as least vulnerable, and the simulations conducted for this study suggest that its yield varies least from year to year. (The cultivation of *niebe* still entails risk; the difference between a good year of rain and a bad year of rain can affect production by more than 50 percent.)

If we compare proportions of crops cultivated by different livelihoods rather than geography, smaller differences appear. In both the north and the south, livestock-dependent households farm a smaller proportion of groundnuts than the two other household types. Households with strategies dominated by crop farming report farming slightly more *niebe* than households of the two other livelihood types in both the North and South. Differences in the proportions of millet, sorghum, and maize cultivated by households of the different livelihood types are less significant, and less consistent between the northern and southern sub-zones.

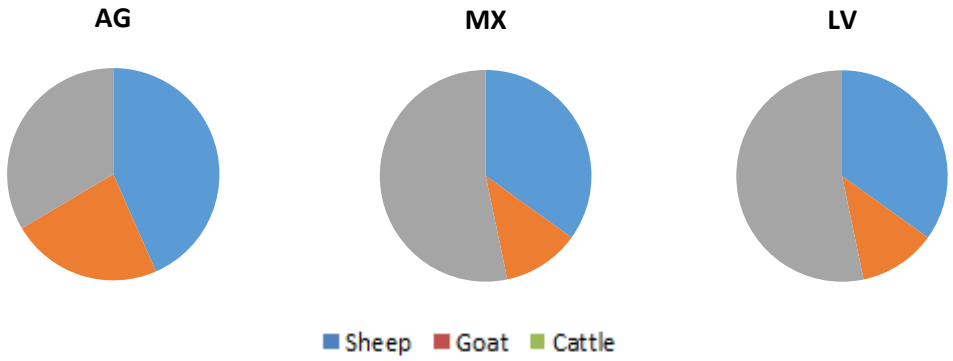
FIGURES 5 (TOP) AND 6 (BOTTOM): CROP PORTFOLIOS, NORTH (TOP) AND SOUTH (BOTTOM)



4.2.4 Livestock portfolios by livelihood and zone

Household reliance on different types of livestock has been calculated based on reported current holdings (including animals held by others, but not including animals held for others). Animal prices were based on interviews with 10 key informants and discussions with ISRA staff. Interviews were conducted shortly after the Tabaskie (Eid al-Adha) celebration, so it can be assumed that the proportions above represent herds from which sheep fattened for sale prior to the holiday had been removed.

FIGURE 7: PORTFOLIOS OF CATTLE, SHEEP, AND GOATS: NORTH



Comparing the portfolios of the households in the North with those in the South (Figures 7 and 8), we see that, except among crop-dependent households, herds in the North contain a greater proportion of sheep. The charts also show that livestock-dependent households in the South hold significantly higher proportions of cattle relative to small ruminants than in the North. Mixed households follow the same pattern, but to a lesser extent. This finding aligns with our understanding of the relative vulnerability of cattle as compared with sheep and goats. Focus group participants interviewed in the North of the study zone consistently noted that they had responded to decreased rainfall by shifting their holdings from cattle to sheep and goats.

Crop-dependent households, on the other hand, have a much greater proportion of cattle in the North than in the South, with small ruminants (goats primarily) making up the difference in the South. The large proportion of cattle may be a function of the smaller size of livestock herds in the North; therefore, the few cattle owned by these populations represent a greater proportion of wealth held in livestock.

4.2.5 Overall distribution of crop and livestock value

Figure 9 provides a rough depiction of the importance of different sources of production. It compares the value of the crops produced in the 2012/2013 year to each other and to the theoretical productivity of the animals in the herds held. Crops were valued based on prices reported by households in the survey. Livestock herds were valued based on percentages of the total herds sold in the North and the South at prices gathered in field interviews. Relationships within the two types of production (crops and livestock) represent actual proportions, while relationships between crops as a whole, and livestock — the two brown-colored slices — should be taken as indicative.

Given these qualifications, observations nevertheless can be made. The proportion of total value in livestock held by all households is much greater in the North than for their counterparts in the South, with the most striking difference between crop-dependent households, for which that proportion more than doubles in the North.

The fact that the proportion of livestock in the southern livestock-dependent livelihoods resembles that of mixed livelihoods in the North also reflects the importance of livestock in northern households. The size of herds of the livestock-dependent households in the North compared to the crops they produce contrasts remarkably with the relatively minor importance given to livestock in the agricultural households in the South. In these graphs, where goats and sheep share one color, the relative equal proportion of small ruminants to cattle in all livelihoods other than the agricultural-dependent households, especially those in the North, also stands out.

FIGURE 8: PORTFOLIOS OF CATTLE, SHEEP, AND GOATS: SOUTH

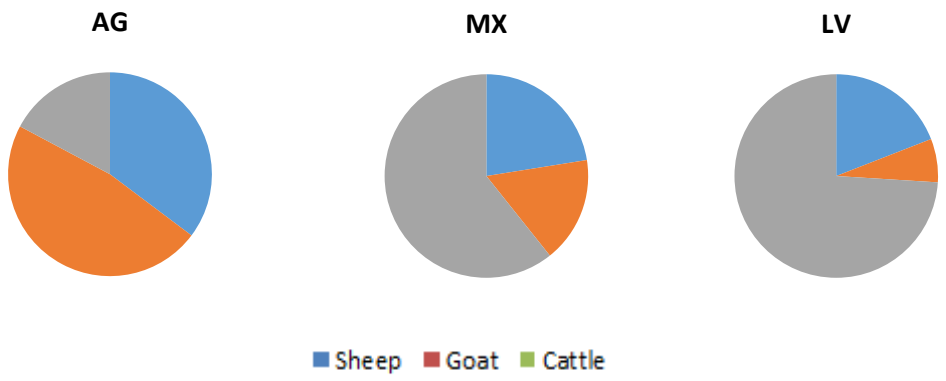
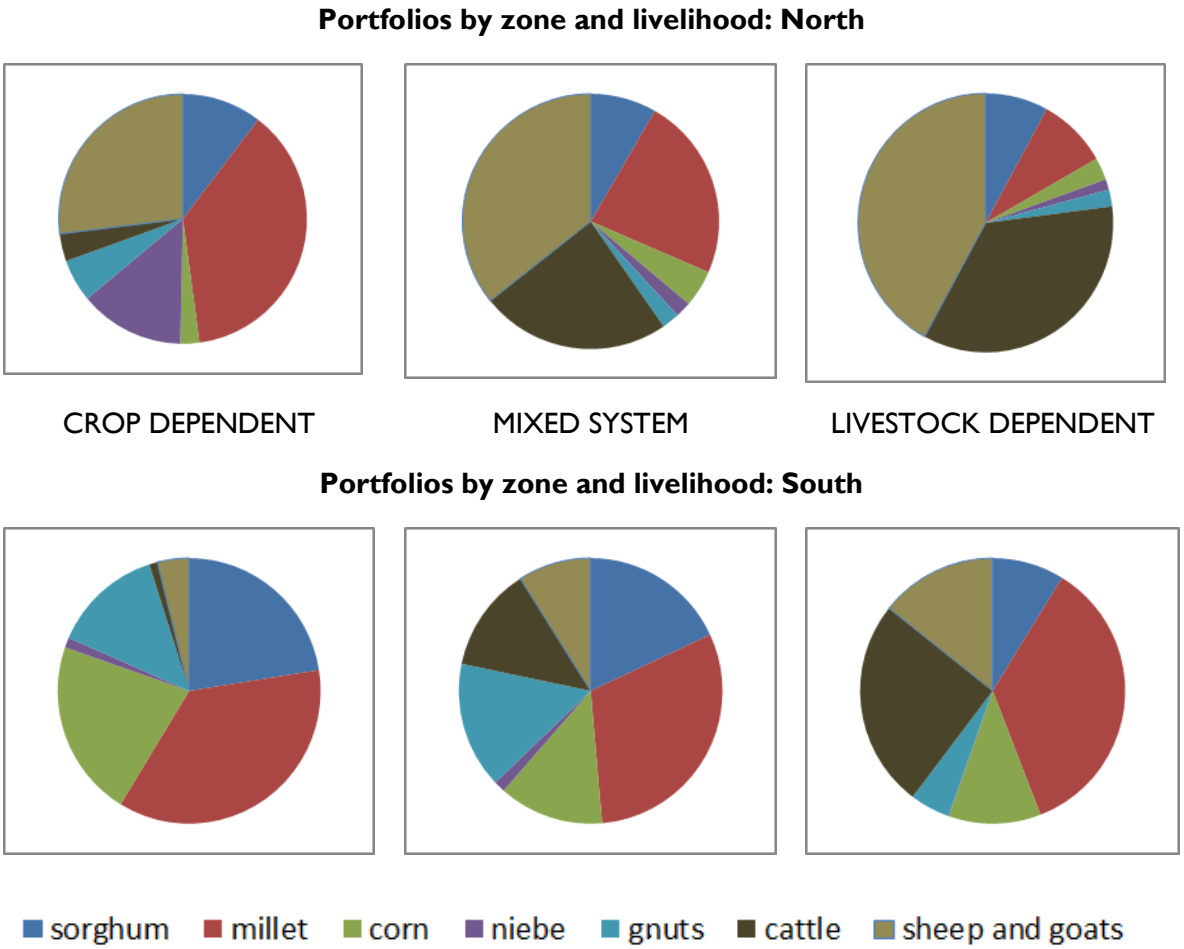


FIGURE 9: IMPORTANCE OF CROPS AND ANIMALS IN LIVELIHOOD PORTFOLIOS



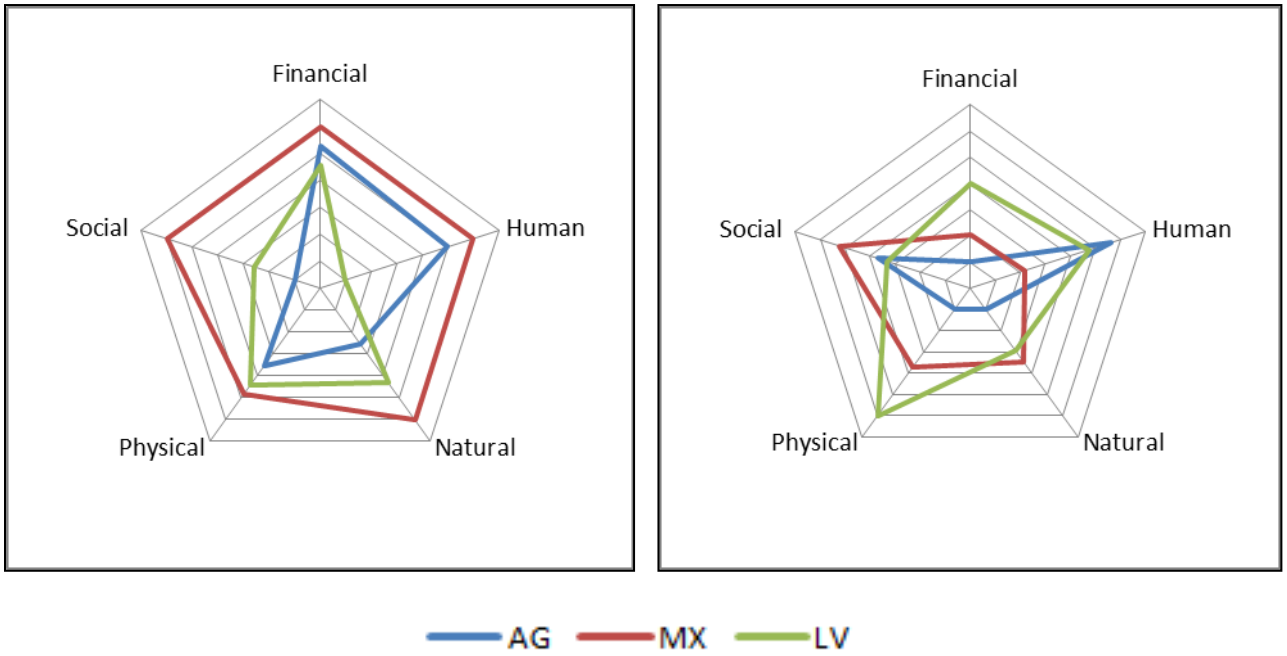
4.3 ADAPTIVE CAPACITY: CURRENT RELATIVE CAPACITY OF HOUSEHOLD TYPES BY LIVELIHOOD TYPE

Measurement of the capacity of households of different livelihood systems to adapt to adversity, including climate variability and change, has been measured using two different types of data collected in the household survey. The first type, AC1, represents the assets held by households. These assets are broken down into the standard five categories of sustainable livelihood assets: human, social, physical, natural and financial. The second type, referred to here as AC2, represents indicators of household stress, general vulnerability, or declining conditions for production. (They resemble indicators of "sensitivity" used in other climate change vulnerability assessments.)

TABLE 15: SUSTAINABLE LIVELIHOOD ASSETS MEASURES FROM THE HOUSEHOLD SURVEY (AC1)

Asset Class	Variable Name	Description	North			South		
			AG	MX	LV	AG	MX	LV
Human	Dependency ratio	Ratio (non-producers/producers)	1.4	1.2	1.5	1.3	1.3	1.3
Human	Education Score	Avg. HH ed. score (age-adjusted)	0.18	0.15	0.13	0.17	0.1	0.15
Social	Social capital index	Index	6.73	14.14	9.07	10.73	12.97	10.18
Physical	Asset Index	Index	631	813	825	763	1047	1274
Physical	Housing Index	Index (walls, roof, floor materials)	94.27	102.04	105.92	73.88	114.91	126.11
Physical	Water quality	% HH w/ piped in water	14.5	14.8	12.3	7	4.2	6.7
Natural	Land quality (walo, jeri)	% HH that farm walo	16.1	29.6	26.2	1	0	0
Natural	Land quantity	Ha per adult equivalent	1.5	0.72	0.25	1.41	0.89	0.42
Natural	Market vegetables	% HH producing	0.03	0.06	0.05	0.04	0.07	0.05
Natural	TLU/Adult Equivalent	number	0.17	1	2.8	0.15	1.3	5.02
Financial	Diversity of income sources	number (crop, livestock, livestock product, off-farm)	2.9	3.6	2.8	2.3	2.8	3.2
Financial	Rotating, S&L, or bank account	% HH with some form of savings	27.4	27.2	32.3	14	32.6	42.2
Financial	Climate neutral income	% HH w/ at least one climate neutral income (excluding migration)	82.3	67.9	69.2	61	56.8	68.9
Financial	Substantial remittances	% HH receiving +50% of total HH income	18.4	33.2	36.9	9	21.1	28.9
Financial	Value crops sold/value crops produced	CFA	1	0.19	0.02	0.74	0.12	0
Financial	Value livestock sold/value herd	CFA	0.15	0.33	0.24	0.16	0.13	0.07

FIGURE 10: HOUSEHOLD ADAPTIVE CAPACITY BY ZONE AND LIVELIHOOD (AC1), NORTH (LEFT); SOUTH (RIGHT)



4.3.1 AC1: Sustainable livelihood assets

The values in Table 15, presented visually in Figure 10, describe the relative assets of different livelihoods by the sub-zones of the study. For these diagrams, the values of each variable in the table have been rescaled to values between 0 and 1, and then averaged within each category. Each category — financial, human, physical, social, and natural — has been given equal weight.

Comparing the diagrams north to south, one sees that there is little overall difference in total assets between the two zones; the average total scores of the two sets of three livelihoods are similar. Differences arise, though, when looking at the individual livelihoods. By this measure, both crop-dependent and mixed systems are "wealthier" in the North than in the South. The reverse is true for livestock-dependent households; those in the South are wealthier. Comparing across all livelihood categories, North and South, the mixed systems in the North scored highest. They sell the most livestock, have the densest social networks, and least frequently report that their herds decreased in size over the past decade. Livestock-dependent households in the South scored second strongest; they have the most valuable houses and physical assets. They also most frequently have savings accounts of one form or another. Of all livelihoods, North and South, crop-dependent households in the South are the poorest and scored least well; they have the poorest quality houses, save least frequently, receive the least income from remittances, and most frequently report having lost farmland during the past decade.

4.3.2 AC2: Signs of livelihood stress

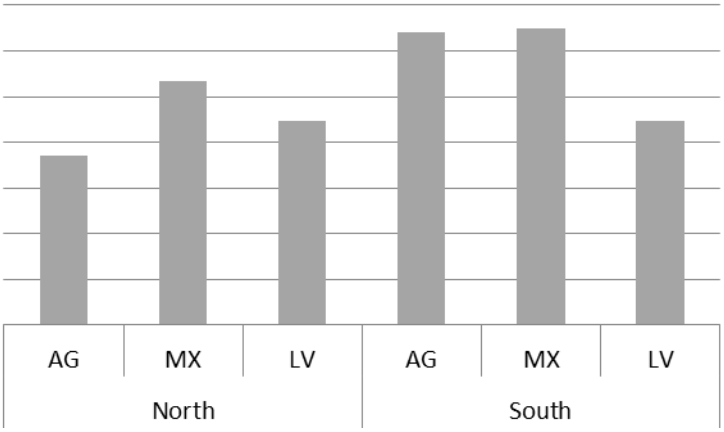
The values presented in Table 16 and Figure 11 show results from a second set of indicators of adaptive capacity; these measure signs of livelihood stress. Globally, they describe households that experience significant stress across a variety of measures. At least one-quarter of households in all categories report declining herds during the past decade, and more than one-fifth of all households in each livelihood group report farming less land during the same period. They also report an average of almost five months of food deficit across the past 12 months.

TABLE 16: AC2 – STRESS, GENERAL VULNERABILITY, AND DECLINING CONDITIONS FOR PRODUCTION

Variable Name	Description	North			South		
		AG	MX	LV	AG	MX	LV
Food insecurity	Avg. number of months	6.30	6.20	5.10	4.40	3.60	2.80
Lost days due to illness or injury	%HH	46.80	51.90	43.10	58.00	60.00	40.00
Dietary diversity and quality (higher less diverse)	number	28.00	31.00	29.00	41.00	36.00	37.00
Chronic illness	%HH	66.10	66.70	58.50	78.00	76.80	66.70
Refused access to livestock resources	%HH	6.50	4.90	7.70	6.00	6.30	4.40
Sheep and goats herd decreased in the past 10 years	%HH	61.30	75.00	68.10	26.60	48.60	53.90
Cattle herd decreased in the past 10 years	%HH	24.20	66.10	63.60	25.30	57.60	62.20
Lost land in the past 10 years	%HH	22.60	21.00	20.00	30.00	24.20	24.40
Not enough land currently	%HH	32.30	44.40	44.60	65.00	62.10	68.90

If we group results by livelihood and across zones, we find that livestock-dependent households reported the least stress, and mixed-system households the most. If we compare individual livelihood types in different zones, the biggest contrast is between crop-dependent households in the two regions. Here, we see that crop-dependent households in the North report the least stress, while crop-dependent (and mixed) households in the South report the most. In fact on several of the indicators, they fall on opposite extremes. Crop-dependent households in the North most often report having enough land, and stable or growing cattle herds; those of this livelihood type in the South most often need more land and have seen their cattle herds decrease. Crop-dependent households in the North score highest on dietary diversity; those in the South score the lowest.

FIGURE 11: AC2 STRESS INDICATORS BY ZONE AND LIVELIHOOD, AVERAGED AND RESCALED



Note: The taller the column, the greater the stress.

Greater detail helps explain this contrast. In terms of assets (ACI), it is true that crop-dependent households in the North scored stronger than the households of that livelihood in the South, but not by much. Yet if we look at these numbers more closely, we notice that households of this livelihood in the North score higher in all classes of assets except human and social. In the financial category, in particular, they score higher, sometimes significantly so, across all indicators but one. They have more diversified income sources, more climate-neutral income, derive more income from selling their crops, have more savings instruments, and receive a greater percentage of their income in remittances. Geographically, compared to those in the South, the crop-dependent farmers in the North live in larger villages closer to national roads and cities. Thus, these crop-dependent households may report they have enough land because, due to the risks to crop farming in the North, they are investing in other income sources such as their growing herds of small ruminants. They have higher dietary diversity because their location provides access to more types of food, and they have the income to purchase it.

Greater detail also helps explain contrasts concerning access to natural resources for livestock. Although fewer than 10 percent of households across the study zone reported being refused access to natural resources for their livestock, the differences between the two study sub-zones are significant. Livestock-dominant households in the North reported most frequently being denied access, while those in the South reported it less frequently. The general greater availability of pasture in the South only partially explains this contrast. Reliance on livestock mobility also comes into play. As shown in Table 17, approximately 30 percent of livestock-dependent and mixed-system households in the North send or take their herds to pasture greater than 10km from their village during dry season. More broadly, livestock-dependent households in the North send (or travel with) their cattle more often and for longer distances than those in the South.

TABLE 17: MOBILITY AND LIVESTOCK IN THE STUDY ZONE

	North			South		
	AG	MX	LV	AG	MX	LV
Avg. number of HH members who go on transhumance	3.23	18.52	23.08	6.00	13.68	6.67
Percentage of HHs who pasture their herds more than 10km from their village during dry season	4.84	29.63	35.38	3.00	11.58	11.11

This measurement of stressors on livelihoods does not provide a ranking of livelihood types identical to measurement by household assets. Mixed systems in the South show the greatest contrast; they report the greatest stress yet score highly in terms of assets. That said, the extremes of the two measurements do align relatively well. Livestock-dependent households in the South are second wealthiest and experience the second least stress. On the other end of the spectrum, crop-dependent households in that same region are the least wealthy and rank second-highest in terms of stress. If we average the scores generated by these two measures, mixed-system households in the North score highest, and crop-dependent households in the South score least well.

Our understanding of the climate risk in the two zones and focus group discussions may suggest some reasons for this pattern. Better-off households in the North have the resources to balance their investments across crop farming and livestock holding, thereby diversifying risk in this zone where climate is less predictable. Households with greater wealth in the less vulnerable south, on the other hand, have followed the trend reported by focus group participants — increasingly investing in livestock, which is seen to be both less vulnerable to climate, and having an income-earning livelihood strategy. Households with the least capacity, those who predominantly cultivate crops and own less livestock, are less able to diversify, and less able to invest in the increasingly cash-intensive animal husbandry sector.

4.3.3 External resources for adaptation: local institutions and markets

Local institutions and adaptation

Institutions are critical to adaptation to climate change. A community's own institutions shape its response and mediate its relationships with outside institutions. These external institutions may play an important role in shaping and strengthening a community's adaptive capacity. Critical to the ability of these institutions to support adaptation are their authority, resources, and internal capacity. It is also important for them to build knowledge about the climatic threats communities face and to integrate this understanding into their planning and collaboration with other institutions. The section below assesses the extent to which institutions of the study zone have demonstrated a capacity to strengthen local adaptive capacity.

Rural Communities: Multiple studies and the key informant interviews conducted for this assessment indicate that administrative decentralization has not kept up with political decentralization in Senegal, and the Councils have neither the financial nor technical resources to perform effectively. They also face human and institutional capacity constraints. Nor is their authority clearly recognized by their constituents.

A number of factors limit the authority and impact of the Rural Councils (*Communauté Rurale*; CR). Limited financial resources may be the most important immediate cause of their lack of influence, but certainly not the only constraint they face. A survey of nine villages in three CRs in the department of

Bakel in 2009 sheds light on the relationship between CRs and the villages under their jurisdiction (ENDA/LEAD, 2009). The report identified a significant gap in understanding and confidence between the CRs and their constituents.

Only four of the nine villages studied reported receiving any support from their CR. (They received food assistance, equipment and furniture for schools, and agricultural inputs.) Presumably, with larger budgets, CRs would have provided more, yet their budgets are small in large part because citizens pay only a small proportion of local taxes, the source of financing for CRs.

A misunderstanding of the relationship between CRs and their constituents may undermine the trust necessary for effective taxation. Community members generally understand the responsibilities of the CRs (although, in some of the villages interviewed in the 2009 study, women had a much weaker understanding .) Yet community members are not aware of a fundamental element in the relationship between CRs and their constituents: accountability. The members of only one of the nine villages surveyed believed CRs have a responsibility to inform them of their deliberations, the decisions they make, and the details of the budget. Further, members of the CR are perceived as being political, and elections limited to candidates appointed by parties. Interviewees in only one of the nine villages in the 2009 survey reported that the CR takes their interests into consideration. (The one village whose members do feel represented has a disproportionate number of representatives in the CR, 10 of a total of 26.)

A study undertaken at the national scale adds to this local study by describing internal factors that limit the CRs from capitalizing on their responsibilities in the decentralization process (UNDP and GoS, n.d.):

- a lack of commitment from elected officials to assume their new responsibilities;
- insufficient coordination between, and integration of, interventions;
- a lack of communication between staff;
- insufficient technical expertise at the local level; and
- limited capacity to make decisions.

These limitations in overall effectiveness undermine any capacity Rural Communities may have in supporting their districts in adaptation to climate change. Members of Rural Councils interviewed for this assessment were all aware of climate variation and shocks in the study zone. In some cases, though definitely not all, trends in climate such as rising temperatures, increasing frequency of flood, and decreasing rainfall were noted. In as many cases as not, though, this change was attributed to natural fluctuations; none expressed a clear appreciation of anthropogenic climate change and none were aware of the national government's adaptation plan. Nor were any of the interviewed CRs implementing projects specifically designed to address climate change. Four of the Rural Council presidents, three in the South and one in the North, mentioned projects to address deforestation. Such projects may alleviate some of the impact of climate change, but they were not seen by interviewees in this light.

Decentralized Technical Services: In key informant interviews, staff of the DRDRs and SDDRs identified gaps in personnel and training. They also stated that they lack sufficient means of transportation and communication; nor do they feel they can adequately access relevant and current information. Further, technical agents often are assigned to regions about which they have little knowledge. Even such essential equipment as a cold chain for vaccines is not assured. In focus group interviews, participants reported little contact with these institutions; of survey respondents, only 4.9 percent reported receiving help from a government source.

Staff members of the DRDR and SDDR who were interviewed recognize that rural council members know the needs of their communities, but these elected local officials do not coordinate their activities with the DRDR and SDDR. Rural development plans, the formal planning instrument developed by communities, are five years old, and reportedly no longer relevant. Technical agents noted that even in urgent cases, such as floods, rural council members did not seek them out for support.

Members of these services all demonstrated an awareness of specific climate shocks and threats in the study zone. They are also all aware of climate change. Yet they were not aware of national-level adaptation policy, and the provision of support to communities to help them adapt to climate change has not yet become an explicit element of their work. Two SDDRs in the South have participated in meetings with the NGO ENDA and the FAO that raised their awareness concerning climate change. The DRDRs have access to weather information, and they do engage in activities that address current climate threats, such as sharing information about new seed varieties, early warning activities, and response to flooding.

Project Staff: Projects, which have capacity often overshadowing that of either Rural Councils or decentralized technical services, do not constitute part of the formal government structure and are limited in duration and geographic reach. Outside of their project zone, their effects are little felt. In focus group interviews in the 15 villages studied, participants reported little contact with projects, and only 5.1 percent of households in the survey reported receiving help from NGOs.

Within their project zone, the contacted projects address the challenges in both crop agriculture and livestock raising. Some, such as SAED and PAPIL, focus more directly on crop farming, while others, such as GRDR and PRODAM, more clearly support both crop farming and mixed as well as semi-sedentary livestock raising. The emphasis largely depends on the target zone of the project.

Project staff were all aware of specific climate shocks and threats in the study zone and demonstrated a greater awareness of global climate change, which they can relate to their programs. The two international NGOs interviewed for this study do not have programs specifically focusing on climate change adaptation. They do, however, implement activities designed to address the vulnerability of local livelihoods to current climate threats and variations. The French NGO *Groupe de Recherche et de Réalisation pour le Développement Rural* is raising awareness of short-cycle seed varieties. The objective of the EDNA LEAD project, active in the department of Bakel, is to reinforce commercial activity. At the outset of this project, EDNA LEAD conducted local research to help integrate climate change considerations into the design. Among other activities, the project is currently supporting small-scale irrigation and the transition from cattle-raising to raising sheep and goats.

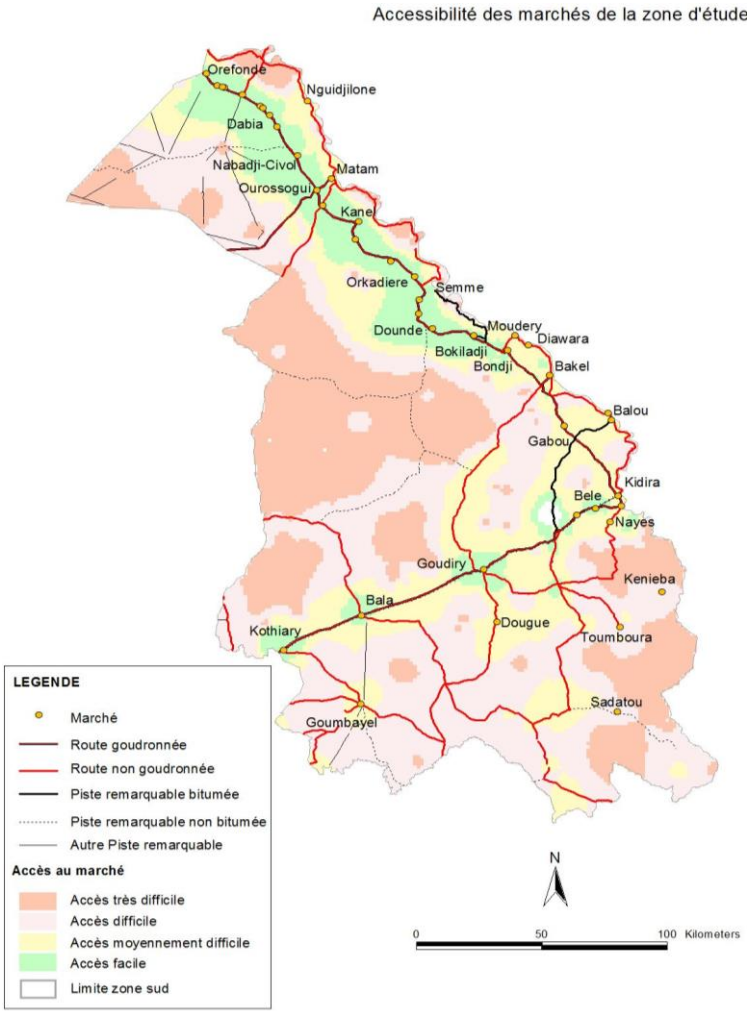
Climate change is more evident in the programming of the donor-funded projects in the study zone. While not specifically designed to address the impact of climate change, and although none of its budget is allocated to this objective, the USAID-funded Yaajeende project, through its focus on food security, introduces practices and technical skills that contribute to the adaptation of crop agriculture in these regions. (For greater detail on the relationship between Yaajeende and climate change, see Oxfam, 2013.)

The World Bank-funded project PROGEDE also promotes practices that build resilience in agriculture and has hired a consultant to incorporate climate change awareness into the next phase of the project. SAED, a semi-autonomous governmental agency, has been present on the Senegal River since the 1960s and has a greater chance of implementing activities over extended periods of time. With the support of Africa Rice, this institution has recruited a technical advisor working on climate change. Interviewed staff reported that the institution's research and development activities have dedicated funding to address climate change.

Access to institutions by livelihood

The key informant interviews conducted for this study did not detect a clear difference between the quality of services institutions offer to communities, either by geographic zone or livelihood. Nor were biases detected with regard to support to different livelihoods. The national government's relationship to the two livelihoods being considered was nevertheless reflected in the focus groups and the household survey. As mentioned above, tradition as well as land tenure law in Senegal favors persons who put land to productive use. And the government's programs for agricultural growth — such as the Grand Offensive on Food Security (GOANA) — combine with land-extensive agricultural systems to drive continued conversion of land to agricultural purposes. In focus group interviews, participants frequently spoke of tensions over land and pasture. In the South, in particular, they spoke of loss of pasture and forage to large herds from the North, deforestation, and bush fires. As noted above, more than 20 percent of households also reported farming less land now than 10 years ago, and approximately 5 percent of all households reported having been refused access to livestock resources in the past year. Key herders interviewed, as well as focus group members, clearly voiced their desire that the government play a greater role in mediating these tensions and the conflicts that stem from them. Given the extremely limited contact between these communities and the government, either national or decentralized, the current relationship between government and the two livelihoods is best characterized by its absence.

MAP 6: CSE ANALYSIS OF MARKET ACCESS



Markets and adaptation

Markets may play a significant role in household strategies to adapt to climate variability and change. Senegal meets only 55 percent of its food needs through production within the country (CSA, 2010). It is a net importer of beef and milk. In the study zone, while the number of months covered by domestic production was not quantified in the survey, households did report an average of almost five months of food insecurity in the previous 12 months — meals that would be completed through food purchases if cash was available. Although grains constitute the foundation of the crop agriculture in the study zone, the gap between production and consumption creates a strong local demand for grains. For households to use markets effectively to meet this demand, markets must be accessible and high functioning. Good terms of trade as well as price

stability and predictability improve the use of markets in an adaptation strategy. As noted above, this is not the case in the study zone; the markets of the study zone are not efficient, and prices are elevated and unstable.

Access also presents a serious constraint. Two physical factors largely determine access to markets: road quality and distance. As can be noted in Map 6 on the previous page, the pattern of the roads serving the study zone creates an area of greater access in Matam Department in the North, along NR2, which contrasts with limited access in Kanel. In the South, while NR1 provides access to Bakel, south of this roadway, in Goudiry, communities are much more isolated.

Because markets form along roadways, distances from villages to markets reflect these disparities. Distances to markets across the entire zone are significant for a population that travels largely on foot; only about 42 percent of communities in the study zone fall within 10 km of a market. The northern department of Kanel is comparatively favored in this regard, with 44 percent of its population within 10 km of a market. Goudiry in the South falls at the other extreme, with only 16 percent of inhabitants within 10 km of one of the five markets in this department. And, while Matam (31 percent), and Bakel (31 percent), fall between these two, overall, the communities of the southern zone have significantly less access to markets, with only 25 percent within 10 km of a market, than those in the North, with 35 percent access.

In CSE's analysis of market access conducted for this assessment, road quality and distance to markets were mapped. Map 6 presents the results of this analysis. In addition to considering distance to roads and markets, the analysis also took into account topography and soil type. Four layers were used to create the map. For each layer, areas were scored either one or zero. One point was given to areas within 10 km of a road, as well as those within 10 km of a market. Access to a paved road scored higher than access to a laterite road. The last two layers were added to refine measurement of the quality of non-paved roads and reflect the impact of water on their condition. A score of zero was given to soils associated with lowlands and water retention, as were lands at lower than 100 m elevation. (See Annex K for the complete analysis.)

As can be seen in Map 6, the villages in the eastern portion of Bakel are the most isolated in the study zone; in fact, this area generally is considered the most remote part of the whole country. This is in large part because the Falémé River forms a western boundary, cutting off these villages. Similarly, seasonal rains and runoff isolate villages close to RN2 along the Senegal River north of Matam. (Here, however, some produce, such as rice, is sold over the border to markets in Mauritania.) Few roads serve the small villages of western Kanel, distant from markets. These locations are remote and hard to access all year around. The recent paving of RN3, which runs across the northern edge of this area through Ranerou to Dakar, has greatly improved the flow of goods to and from the whole study area.

For the vast majority of the households in the study zone, markets become most important in the "hungry period" of the months prior to harvest, when the household's own food stores are low or exhausted. Stored wealth becomes critical at this time of the year. Crop farmers depend on cash, often from migration or the sale of groundnuts (in the South) or cowpeas (in the North). Households that raise livestock may sell cattle, or the more "liquid" small ruminants at this time. Better resourced, more diversified households can weather the vagaries of grain prices.

In addition to weathering the bad times, effective use of the market also includes taking advantage of the opportunities presented by price spikes. This strategy relies on timing, producing or storing wealth to have available in times of scarcity. Farmers may diversify into cash crops — groundnuts, cowpeas — and do well when prices spike, but they balance this investment with production for their own subsistence and thus increase dependence on external markets. As a viable alternative, or a complement if there's enough household labor, some farmers of the study zone — predominantly women — have taken up

the production of market vegetables. These vegetables can be watered by hand and are grown in the off-season. Where transportation permits, they can be sold locally.

Livestock owners face similar challenges in integrating the use of markets into a viable livelihood strategy. While maximizing profit may not be their overriding objective, they do depend on markets to gain income, in addition to meeting needs in normal times as well as times of crisis. Livestock owners farm crops for domestic consumption, and, thanks to available manure, tend to have higher-than-average yields. They are less likely to be able to meet their own cereal needs than full-time crop farmers, and they depend on the market more frequently, selling milk products and exchanging the wealth stored in livestock for food purchases in times of poor production. The primary options available in herder marketing strategies include determining the timing of sales and the type of animal to be sold. In times of crisis, when a household must sell animals, this choice is limited to the latter; markets provide minimal relief in times of severe drought, which often coincide with market saturation and lowered prices.

Limited access to markets may give an advantage to households with their wealth on the hoof; mobility is built into the livestock production system. In this zone, where agriculture surplus is rare, raising livestock provides a better way to store capital over time. For households with the resources to do so, the strongest strategy to manage agricultural risk is often to produce a larger range of products to store and sell, thus creating a more diversified relationship to markets through the integration of crop and livestock production.

5.0 HOW WILL CLIMATE CHANGE IMPACT VULNERABILITY?

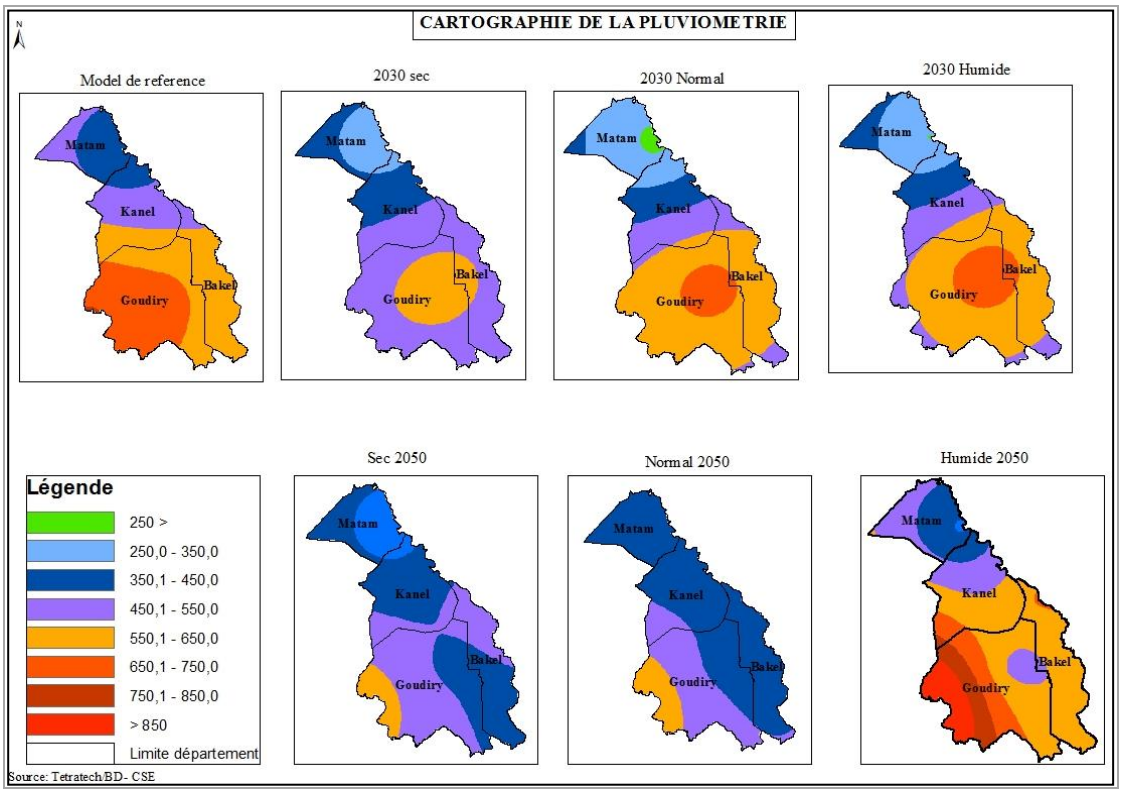
5.1 CLIMATE PROJECTIONS

5.1.1 Rainfall

Most of the models project a reduction in rainfall on the order of the one observed in the 1970-1990 period. This prediction is consistent with regional trends presented in IPCC reports of the potential drying of the western Sahel. Here, the study team was able to provide a context in terms of rainfall changes observed in the past; the team also gained insight into the spatial distribution of the projected changes within our region of interest. While projecting an overall drying of the area, different models project different levels of drying: for example, the model that generated the driest conditions in the region for 2030 projects a stronger drying in the southern part of the region, while the wettest model projects only limited drying in the South but much drier conditions in the North for the same period. The spread is even greater for 2050; the driest model projects that current conditions found in the North might prevail in the South and that the North will be only slightly drier, while the wettest model projects conditions similar to current ones in the North and wetter in the southwest of the region. (See Figure 12 for mapped projections.) Across the study zone, as climate change is also expected to increase variability, the probability of dry spells and exceptionally dry years may also be higher than in this historical period.

Interestingly, models also project seasonality of changes similar to the one that occurred in the 1970s, with a systematic decrease in rainfall in the northern stations, and an occasional increase in rainfall in the early rainy season in southern stations.

FIGURE 12: DOWNSCALED PROJECTED CHANGES IN ANNUAL RAINFALL AMOUNTS 2030 AND 2050

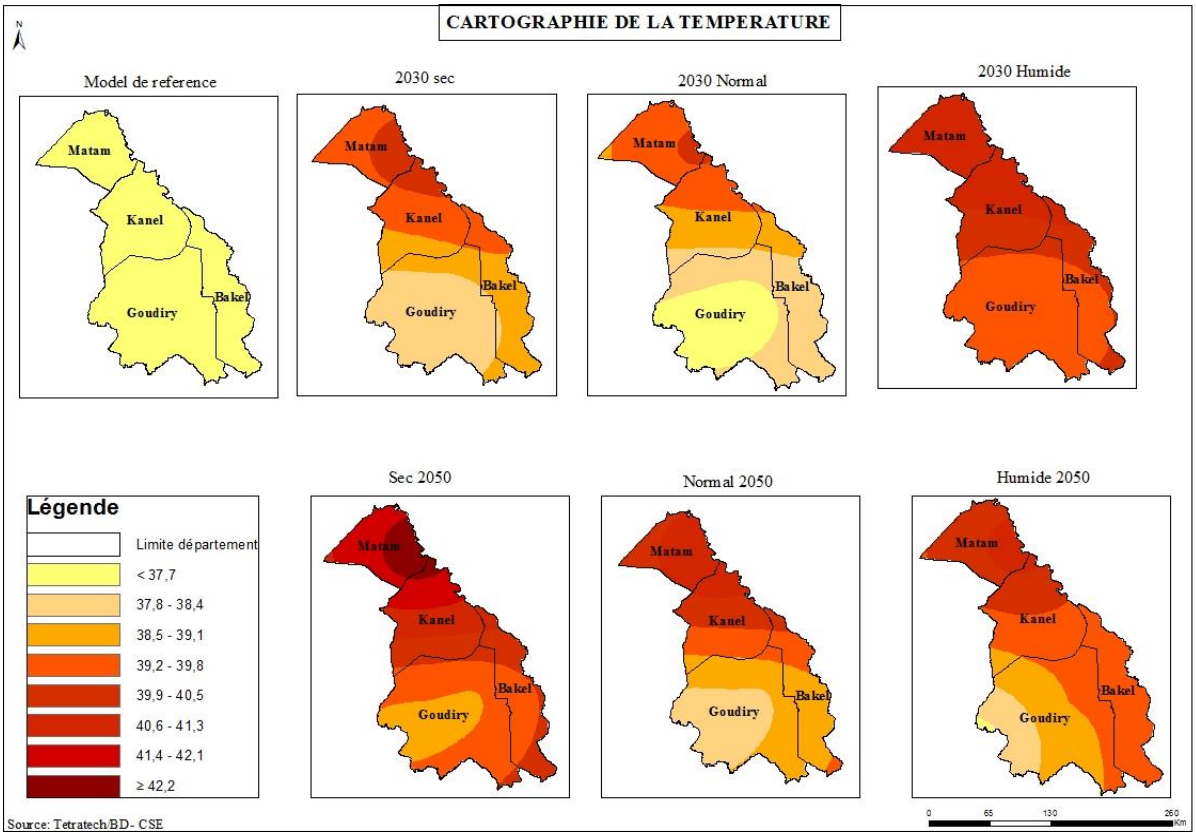


5.1.2 Temperature

A consistent increase in maximum and minimum temperature is projected across all the stations, ranging from 2 °C to over 5 °C in selected months. This increase is also consistent with predicted regional trends, but we were able to estimate potential changes in different months. The greatest increases in maximum temperatures are projected for December-February and June-September — currently the coldest seasons, flattening the seasonal cycle. However, even the more limited increase during the warmest months of April-May brings monthly averages close to 45 °C, as opposed to current monthly averages of approximately 40 °C.

The increase is consistently stronger in the North and for 2050. With the exception of the wettest model for 2030, which simulates the strongest and wide-spread increase in temperature, regions with the smallest decrease in rainfall are also projected to warm the least.

FIGURE 13: DOWNSCALED PROJECTED CHANGES IN TEMPERATURE, 2030 AND 2050



It is important to realize that, while most of the models project a return to the drier conditions of the 1970s and1980s, temperatures will be not be the same as they were then. Models consistently project that temperatures will rise, even during the rainy season.

The strong increase in temperature will increase evapotranspirative demand of crops and range-lands, increase water stress, and deplete surface water resources persisting after the end of the rainy season independent of rainfall evolution. Although the magnitude and impact of such changes will be stronger in the drier/hotter path projected by the majority of models than in the wetter path projected by a few models, it is important to evaluate the impacts of both paths.

5.2 EXPOSURE

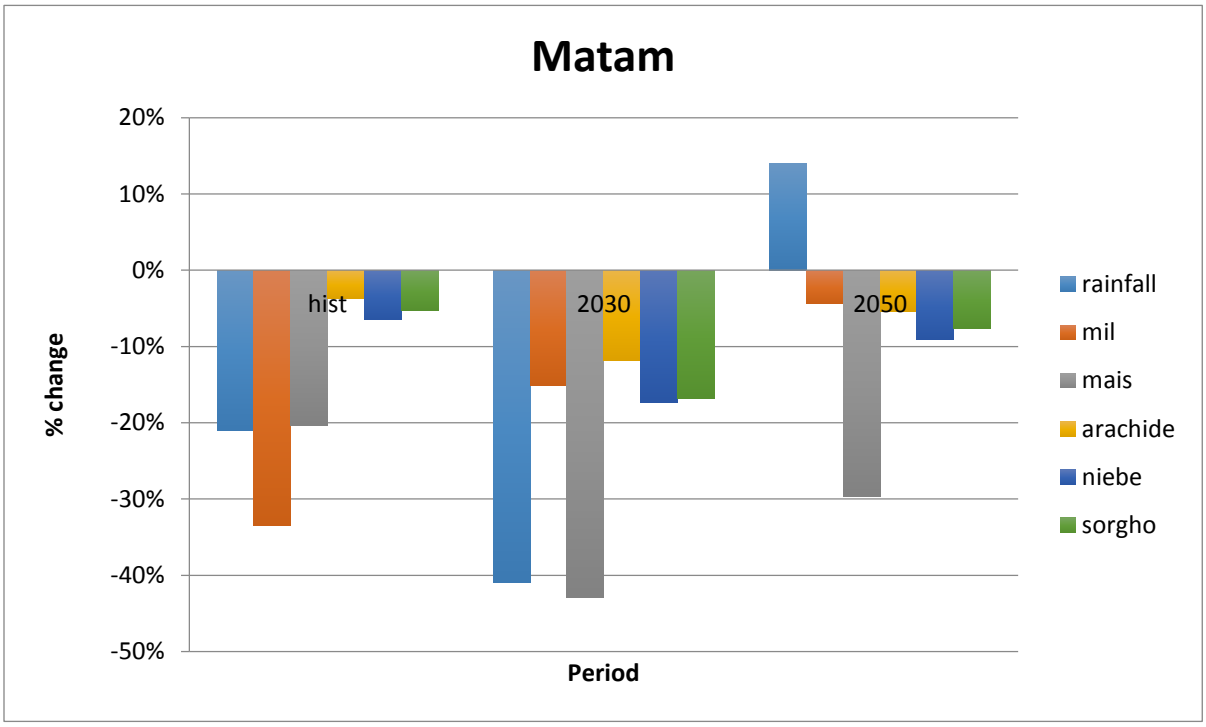
5.2.1 Potential impact on crop productivity

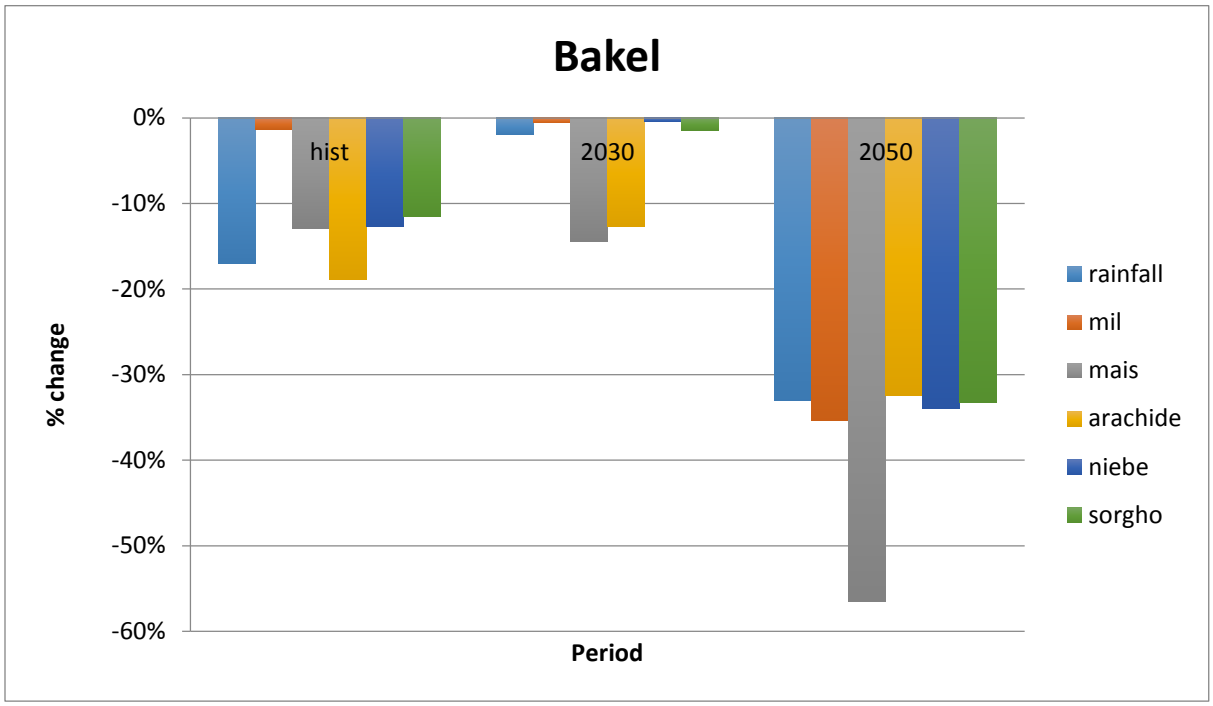
Based on rough climate scenarios, the agronomic study conducted for this assessment concluded that for all of the crops considered, the impact of the worst case projected climatic changes would be significant at all stages of plant development, and most significant at germination and early emergence — the stages during which plants are most vulnerable. Hypothesized increase in temperature and drop in rainfall likely would result in damage at these stages and irreversibly weaken the plant, thus reducing the plant's ability to achieve maximum yield and crop quality. Given the team's assumptions, the major conclusion of the literature review was that climate change will effectively bring an end to rain-fed crop cultivation across the study zone by 2100 (see Annex Q: Potential Climate Change Impacts on the Productivity of Select Agricultural Crops in the ARCC Senegal Vulnerability Assessment Study Zone).

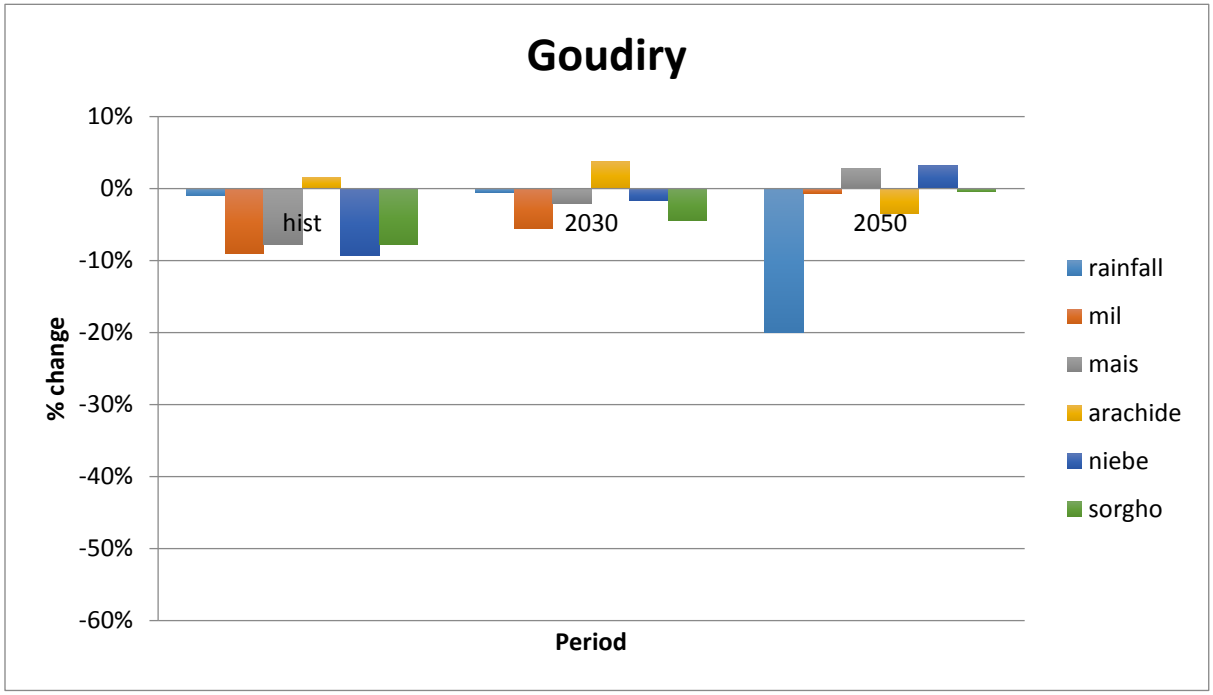
Crop modeling based on observed data and climate projections was conducted to test these conclusions. Figure 13 presents the results. The graphs depict projections of changes in yield for selected crops relative to reference years of 1995 and 1998, the "average" years of the 1991–2010 period. They include comparisons to 1979 and 1987, average years of the earlier, dryer 1971–1990 period, as well as comparison of the reference years to the average projections for the 2030 and 2050 time horizons.

It should be noted that these results contain a high level of uncertainty and should be seen as indicative. As explained further in the methods section, they are based on a limited number of years of historical data and three sets of climate projections. Crops are very sensitive to intra-seasonal rainfall distribution, which, if resources and time allow, could be addressed by simulating a large number of possible daily sequences. Such was not the case in this analysis. Additionally, other factors that significantly affect yields were not taken into account, such as farmer decisions concerning sowing dates. Models produced a range of results, but for the sake of simplicity, only those derived from the model projecting climatic conditions close to the multi-model average results ("average" projections) are presented here. Complete results can be found in Annex Q.

FIGURE 14: CROP MODELING RESULTS FOR THREE STATIONS







Despite the qualifications presented above, some conclusions nevertheless may be drawn. First, with the exception of the 2050 projections in Bakel, changes projected by the most probable model do not differ radically from the changes simulated for the 1971–1990 period. This finding suggests that, even taking temperature into consideration, all else equal, declines in yields for this part of the country may be on the order of those experienced in the 1970s.

Second, a comparison of results for Matam and Goudiry suggest that farmers growing crops in the North do so in a climate context much closer to crop thresholds. Projected changes in temperature and rainfall can be expected to affect yields less dramatically in the South, as has been the case in the past.

Finally, projections of yield anomalies in Bakel, dramatically larger for the 2050 timeframe, reflect the inherent complexity of modeling the erratic climate of the Sahel. Likely explanations include the nature of the intra-seasonal distribution of rainfall in the observational data. Rainfall in the selected year could have begun late, or could have contained a long dry spell at a critical stage for crop growth.

5.2.2 Impact on livestock systems

In attempting to quantify potential changes in the context for livestock production in the study zone, this assessment concentrated on the availability of three critical resources: pasture, water, and agricultural yields, which produce field residue and fodder.

Table 18 presents the results of biomass modeling conducted by CSE and described in the methods section and Annex O. As with the crop modeling, results are presented in terms of change relative to the reference year, in this case 1998. Here, the three columns for the two future time horizons represent results based on three different sets of projections from five stations in or near the study zone, arranged from North to South. The range within each time period indicates the envelope of uncertainty derived from the differences in expected future climates. As can be seen, in each time period (except for Podor in the North and Tambacounda in the South), that envelope ranges from a decrease to an increase in annual produced biomass. Decreases tend to follow a North-to-South pattern but include exceptions. For example, as in other modeling based on this set of data, a large decline in Goudiry in 2050 is projected, as is a dramatic increase in Bakel for 2030 in the case of the wet model. These results are probably linked to the intra-seasonal distribution of rainfall and the issues discussed in the context of crop modeling outputs above.

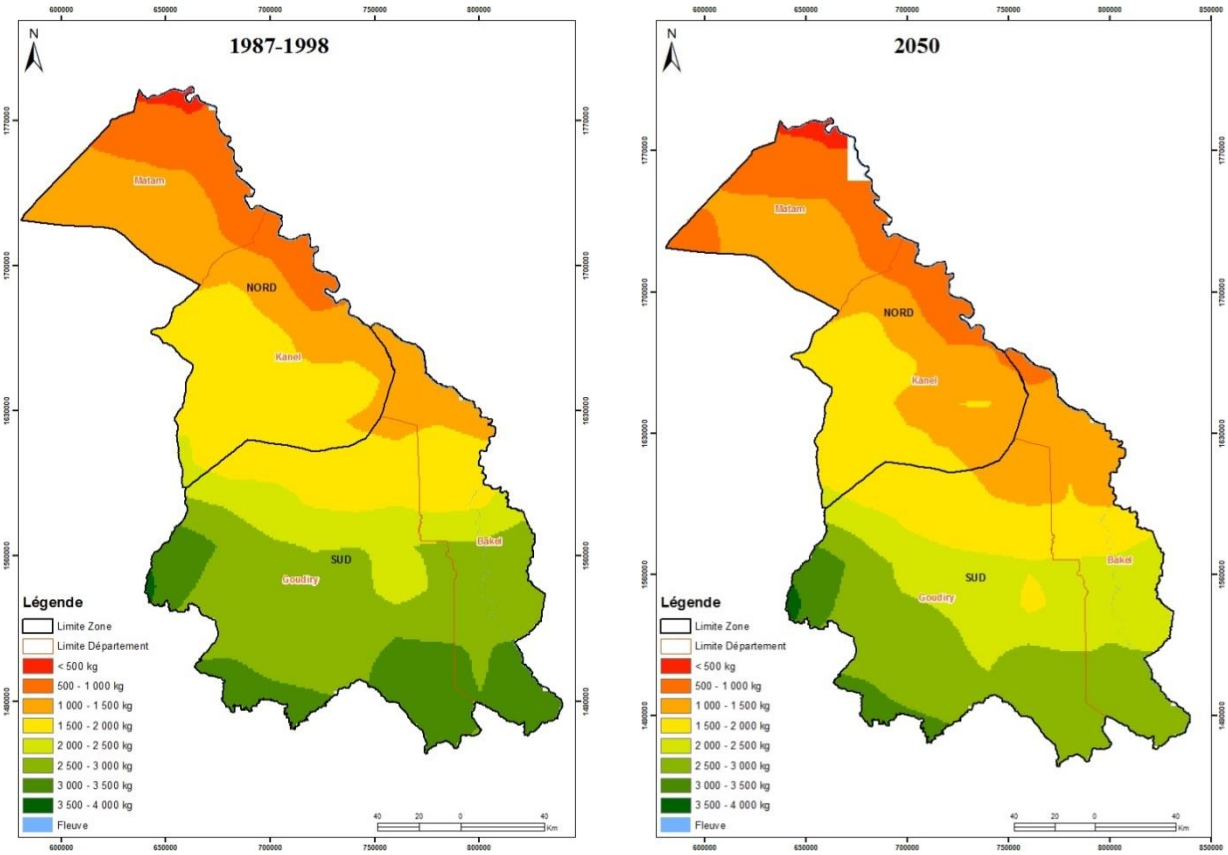
TABLE 18: PROJECTED CHANGE IN BIOMASS RELATIVE TO HISTORICAL AVERAGE YEAR (1998)

	2030			2050		
	Dry	Normal	Wet	Dry	Normal	Wet
	Δ %	Δ %	Δ %	Δ %	Δ %	Δ %
Podor	-0.41	-0.54	-0.17	-0.48	-0.29	-0.36
Matam	-0.31	0.16	0.25	-0.41	0.19	0.24
Bakel	-0.08	0.10	1.49	-0.12	-0.06	1.72
Goudiry	-0.24	-0.01	0.06	-0.33	-0.38	0.03
Tambacounda	-0.07	-0.09	0.17	0.02	0.12	0.59

Results of the modeling have been interpolated across maps of the study zone to produce Figure 15. The maps present raw values, so the changes noted in Table 18 above are seen by comparing the differences in the two maps below. Notice, for example, the greater area covered by the orange sections and the smaller area covered by green in the map on the right. In all cases, as with the crop results, the impact is most dramatic in the North, transitioning to less severe in the South. (A complete set of maps, along with discussion is found in Annex O.)

If livestock populations in the North grow, this shift will very likely produce a deficit in natural pasture.[10] And if herders continue extensive or semi-extensive management practices, pressure will increase on the resources in the South, where focus group participants reported that tensions over resources already exist. These conclusions echo conclusions by Sy regarding the potential for conflict stemming from the lack of management of herds from Mauritania and Mali in the Ferlo (Sy, 2010).

FIGURE 15: CHANGES IN BIOMASS PRODUCTIVITY



Note: Biomass productivity based on observed 1997 and 1998 average (right) and average 2050 model (left).

Impact on livestock disease: Under this assessment, ISRA also conducted a review of the research literature and expert opinion on the potential impact of climate change on disease afflicting livestock in the study zone. The general consensus of this research suggests that climate change will have a very significant impact on the prevalence of livestock diseases across Africa. A number of unknowns prevent greater precision, including uncertainty about the impact of new climatic conditions on pathogen transmission and the immune status of livestock populations. Uncertainty also stems from other factors less dependent on climate. For example, farmers and pastoralists will adopt new techniques for managing

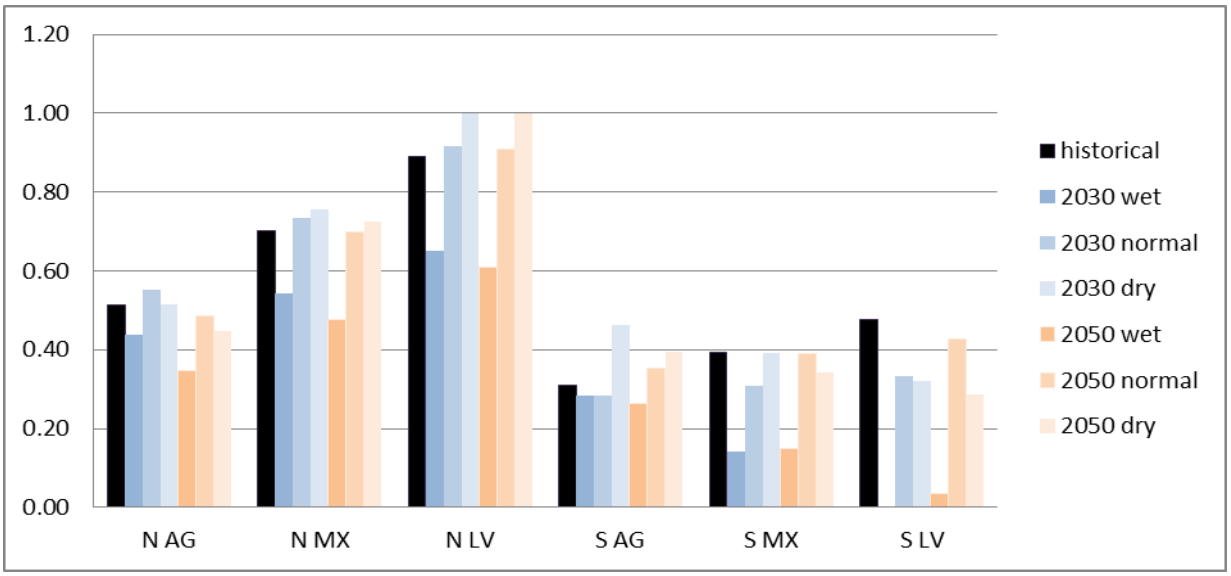
[10] This information is supported by research in the Ferlo region of Senegal that concluded that climate change impacts will not support expected growth in populations and require herders to implement higher destocking rates (Hein, 2009). An English summary of this article, along with abstracts of other research findings, may be found in Annex P.

diseases and likely adopt livestock breeds with different resistance to various pests and diseases. Owners may also move their livestock to new agro-ecological zones that pose a lesser (or greater) risk of infection. Despite these contextual factors, the direction and magnitude of such changes will be strongly influenced by increases or decreases of rainfall amounts. Disease-specific summaries of potential impacts on important livestock diseases in Senegal may be found in Annex J.

5.2.3 Exposure on Crops and Livestock

Figure 16 builds on the above results and compares the three types of production. The height of each bar indicates the level of expected decline in productive potential relative to the reference years of 1995 and 1998 (the average years of the more recent, and wetter, 1991–2010 period). The black bars labeled "historical" compare simulations from 1979 and 1978, (the average years of the dryer historical period, 1971–1990) with simulations from the reference years of 1995 and 1998. The results for crop systems in the North and South (N AG and S AG) average the results across the five crops being considered (sorghum, cowpeas, groundnuts, maize, and millet). The results for livestock systems in the North and South (N LV and S LV) present the average expected decline in biomass production, and by extension, in livestock productivity. The results for mixed systems simply are the average of these two sets of results. For all time periods, calculations also took historical coefficients of variation into account, as variations in the productivity of different crops and biomass are an important factor in climate's impact on productivity.

FIGURE 16: EXPOSURE



***Note**: The height of each bar indicates the level of the modeled impact of temperature and rainfall relative to the reference years.*
***Key**: N AG = crop systems in the North*
N MX = mixed systems in the North
N LV = livestock systems in the North
S AG = crop systems in the South
S MX = mixed systems in the South
S LV = livestock systems in the South

These calculations are limited to responses of crops and biomass to climatic conditions. They do not take into consideration changes farmers will make in their management of crops or livestock, such as the adoption of new crop varieties, adjustments in moisture management, or patterns of livestock movement. Nor do they reflect potential changes in population or the quality of soil, bushfire management, deforestation, or changes in market prices or institutional support. They are based solely on potential changes in temperature and rainfall regimes.

With these limitations in mind, Figure 16 indicates that, under all time horizons, exposure in the North is greater than that in the South for all production systems. In the North, results show differences in the impact of climate on systems; change in climate can be expected to affect biomass availability more strongly than crop yields. In the more humid South, the picture is less clear. As in the North, the dark bars comparing the average years from the 1971–1990 period to the reference years 1995 and 1998 also show a stronger decrease in biomass potential; historically, livestock-based production has been more exposed to climatic variation than crop production.

For both 2030 and 2050 time horizons, results based on the driest and the normal models demonstrate a change in exposure relative to the reference years, which resembles the difference between the driest and normal years of the 1971–1990 period and the reference years. As with the climate projections themselves, projected conditions resemble those of the past. However, if climate follows the path suggested by the wet model, the impacts will be more limited, with livestock systems in the South being the least affected and livestock systems in the North showing the wider range of possible outcomes between the driest and wettest projections.

5.3 SENSITIVITY AND OVERALL LIVELIHOOD VULNERABILITY

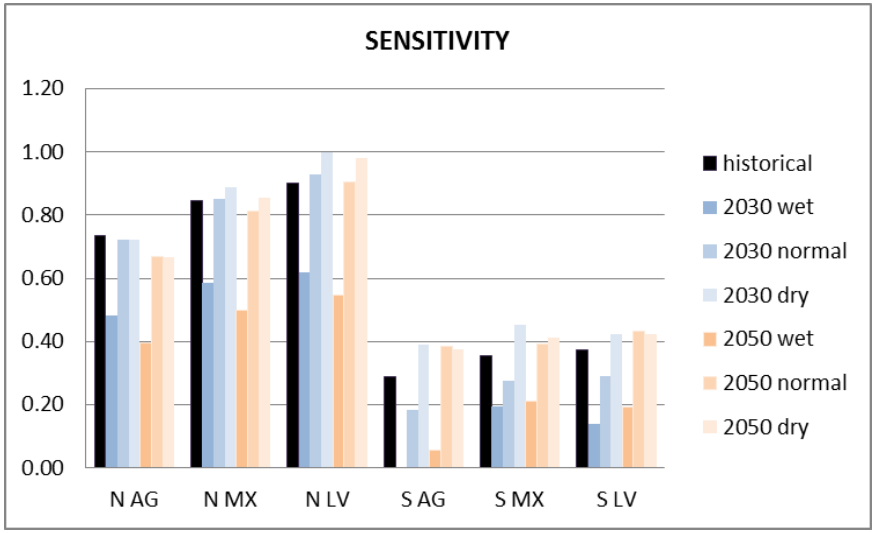
5.3.1 Livelihood sensitivity

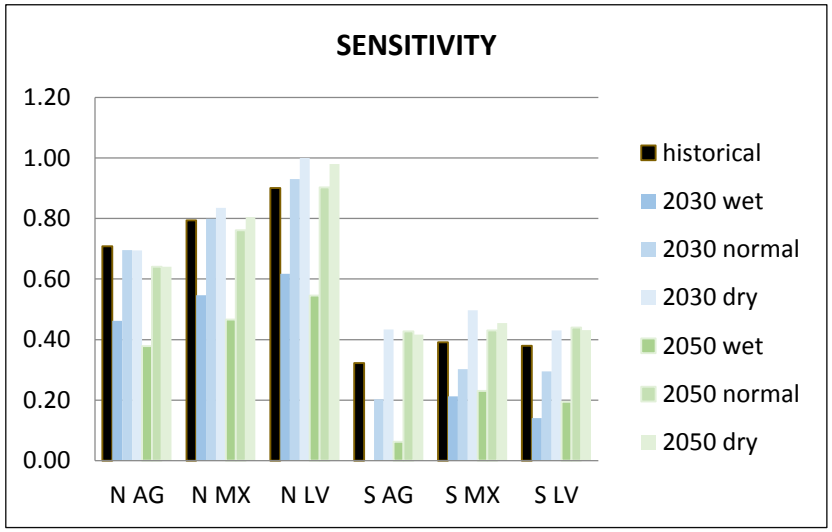
How will the different levels of exposure affect livelihoods? Given the results presented in the previous section, this section will explore how climate may affect the portfolios managed by livelihood types, based on the proportions of different crops and livestock in their farming systems, as presented in the pie charts in Figure 9 (see page 41). For example, one can identify the livelihood types that now depend most heavily on crops whose productivity is expected to decline in the future, as well as the impact of having higher or lower proportions of crops relative to livestock. The modeling efforts conducted for this assessment did not attempt to predict the changes households will make in the distribution of crops and animals in their crop and livestock portfolios between now and 2030 or 2050. What this section explores is the sensitivity of different livelihoods to different climatic regimes based on current portfolios and reliance on off-farm income.

Figure 17 presents these differences. It displays results for the three livelihoods in the North and the South for three time horizons and three projected climate scenarios. The height of the bars represents the relative overall impact climate change will have on each of these portfolios based on the modeled projections and their impact on crop yields and biomass. The higher the bar, the greater the sensitivity.

The graph on the right takes into account non-climate sources of income. It adjusts the results presented on the left with the proportions of income that households receive from migration and off-farm sources, using the figures presented in Table 15 (pages 42-43).

FIGURE 17: LIVELIHOOD SENSITIVITY





***Note**: Relative expected impact of climate change on the agricultural productive systems of different livelihoods (see key below). The higher the bar, the greater the expected impact. The graph on the right presents the same results as on the left, adjusted to take into account livelihood reliance on off-farm income sources. See the following paragraphs for a discussion of the impacts projected by these graphs.*

***Key**:*
N AG = crop systems in the North
N MX = mixed systems in the North
N LV = livestock systems in the North
S AG = crop systems in the South
S MX = mixed systems in the South
S LV = livestock systems in the South

Looking at the graphs, we note that the differences in outcomes based on projections (wet versus normal or dry) are greater than both the differences between time horizons and between livelihoods within each zone. For example, the difference between the wet and dry scenarios for northern livestock-dependent households for 2050 (the darkest and lightest N LV peach columns) is greater than the difference between the projections for the northern livestock 2050 wet years and their results for 2030 wet years (the N LV darkest peach and darkest blue columns), or those of northern crop-dependent households for the 2050 wet time horizon (the N AG darkest peach column). That is to say, the projected climate scenario selected has a greater impact on the results than either the livelihood or year to which it is projected. While taking into consideration this strong spread in results produced by different climate scenarios, we nevertheless propose the following observations:

- Climate, both observed and projected, affects households more in the North than in the South, irrespective of crop and livestock portfolios.
- Agricultural portfolios affect sensitivity more strongly in the North than in the South.
- In the North, livestock-dependent livelihoods systematically score as being more sensitive than crop-dependent and mixed-system livelihoods.
- Despite the less evident impact on portfolios in the South, in this sub-zone crop-dependent households systematically score as being less sensitive than livestock-dependent and mixed-system livelihoods.
- A rough weighting of scores to take into account the percent of income households receive from non-farm sources results in a slight increase in the relative sensitivity of crop-dependent households and mixed-system households in the southern portion of the study. The overall impact, however, is minimal; households tend to compensate for deficits in one area (such as limited off-farm income among livestock-dependent households in the South) with strengths in another (higher rates of migration for that same group).

A number of other factors that this assessment did not attempt to quantify also affect the relative sensitivity of these livelihoods to climate variability, extremes, and change. Had the much higher proportion of sheep and goats in the agricultural households in the North been considered, the relative sensitivity of crop-dependent households there would appear even lower, given the greater natural adaptation of small ruminants to hot, dry conditions. Modeling did not take into account livestock mobility or the fact that herders seasonally bring livestock down from the North. As previously noted, these actions reduce the sensitivity of this system. Given the importance of these and other factors, such as the uncertainty in the projections upon which these results are based, the fact that crop modeling was based on one of a range of available varieties, and the rough manner in which dependence on off-farm income sources and migration remittances were calculated, these results should be seen as illustrative and as an attempt to capture overall tendencies.

5.3.2 Livelihood vulnerability

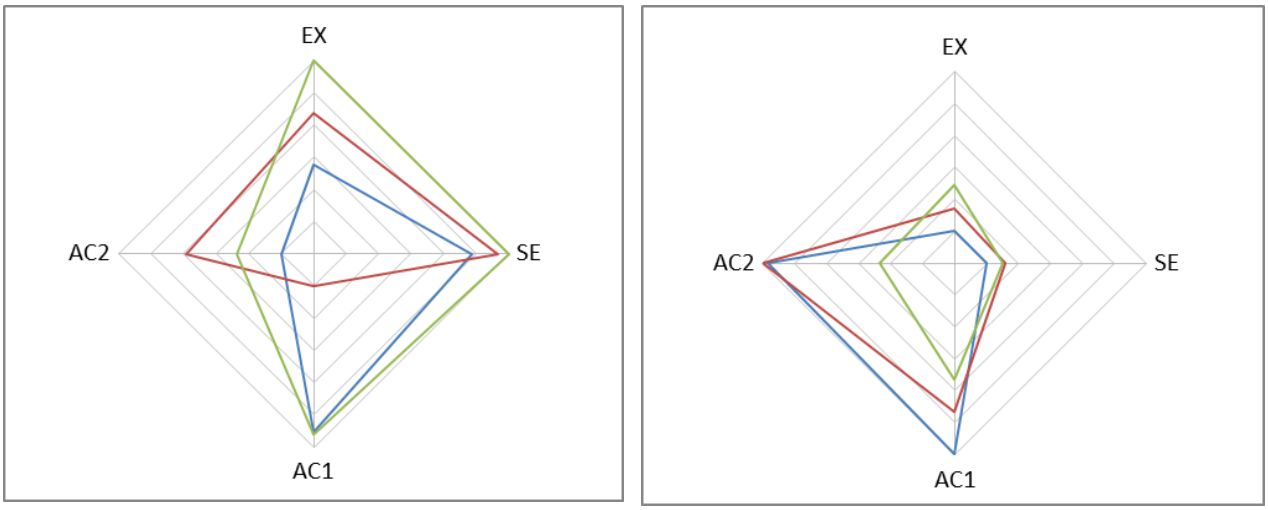
Figure 18 presents overall relative vulnerability for the three livelihood types, in the North and in the South. It summarizes the relative changes in the potential productivity of different production portfolios for the historical and 2050 normal time horizons captured in the section above and presents them in relationship to the other elements of climate change vulnerability studied in this assessment. As in the bar graph above (Figure 16), exposure (EX) presents the results of simulated (historical) and modeled (future) changes in productive systems, with AG representing the change of all crops, and LV the relative change in available biomass relative to the reference years. MX shows the average of AG and LV.

Sensitivity (SE) is the index obtained by aggregating the potential changes in crop and livestock for each livelihood based on their relative contribution to the livelihood and presented in section 4.2.5. The presentation of sensitivity here parallels the data presented in the above bar graphs for the historical climate and for the 2050 normal time horizon. Sensitivity measurements are not weighted with off-farm income, because this measurement is captured on the Adaptive Capacity axis (AC1).

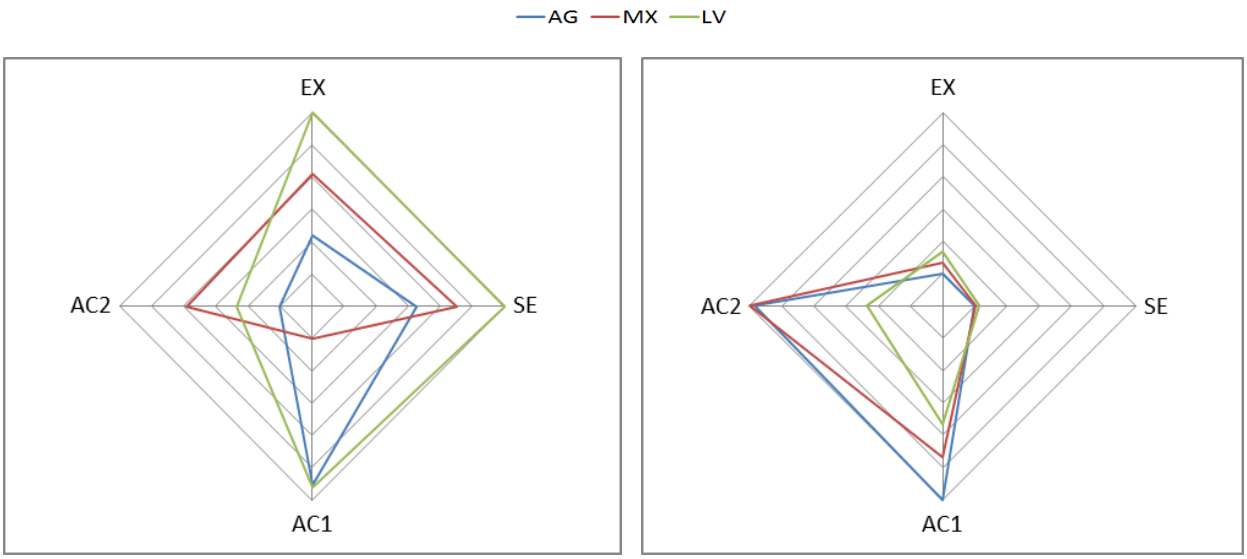
AC1 represents an average of the scores of the sustainable livelihood assets presented and discussed above in section 4.3.1. However, the direction here is reversed to align with the other measures so that distance from the center represents a relative lack of assets. Similarly, AC2, measures of general stress and challenges accessing resources, presents an average of scores described in section 4.3.2. The adaptive capacity values in the graphs below are not based on climate projections and do not change between the historical and 2050 time horizons.

In the diagrams below, all values have been standardized for each vulnerability component on a zero to one scale, with zero attributed to the lowest score among all the livelihoods, and one to the highest. Taken together, the four measurements presented here represent the relative vulnerabilities of the different livelihoods. Greater distance from the center of a given score, or greater area encompassed by the quadrangle formed by the livelihood, indicates greater vulnerability.

FIGURE 18: CLIMATE CHANGE VULNERABILITY BY ZONE AND LIVELIHOOD



North sub-zone, left. South sub-zone, right. Historical exposure and sensitivity above; 2050 normal exposure and sensitivity below.
(The larger the quadrangle, the greater the vulnerability.)



As the individual components have been discussed previously, the value of these very condensed summary diagrams lies in reading them as whole figures. The clearest finding they convey is that the two regions present very different overall images. If we look by livelihood, livestock-dependent households are significantly more vulnerable in the North than in the South. This finding is true regarding adaptive capacity as well as exposure and sensitivity. The diagrams for crop-dominant and mixed systems portray relatively similar levels of vulnerability across the two zones, yet for different reasons. Both are more exposed and more sensitive in the North, but both systems also have more adaptive capacity in that region. Access to assets (AC1), in particular, reduces the vulnerability of crop-dependent households, while less stress reduces the vulnerability of mixed-system households. Overall, livestock-dependent households in the North are the most vulnerable, and those in the South the least. The total scores for the other four categories are all relatively similar and fall between these two.

As pointed out in sections 5.2 and 5.3, the potential changes in climate at the 2030 or 2050 horizons show a wide spread of results regarding exposure and impacts on crops and biomass; they range from conditions similar to those observed in the 1970-1990 period to much more favorable ones. However, if we look at them in the context of Figure 18, here taking the 2050 normal results, they do not change the overall relative vulnerability of the livelihoods from those computed on historical data. In each case, along each axis, the relative vulnerability remains the same. Overall, the livestock livelihoods in the North remain the most vulnerable, and those in the South the least.

In addition to the uncertainty of projections, other factors limit the conclusions of this analysis. Those factors include the lack of dynamic adjustments to production systems, such as changes in portfolio composition; over time, the wealthiest households will take advantage of their resources to shift away from high-risk activities. Thus, the diagrams above may overstate their long-term vulnerability.

Nor do the graphs account for livestock mobility; households in the North are not currently limited to the biomass in the North. As a result, the graphs overstate the exposure and sensitivity of these households, and thus their overall vulnerability. Nevertheless, in the long term, even with significant improvements in the efficiency of food supplement markets, they will continue to rely on southern pasture. Management of southern rangeland, and its ongoing availability to these households, will greatly affect the vulnerability of livestock dependent households in the North.

Further, these graphs do not fully take into account the dynamics of the diversity of holdings; mixed farming systems are able to change their investments between crops and livestock more easily than other households are able to do. They also take advantage of the different types of risk inherent in these two systems in ways that are not represented; having control over these two productive systems reduces risk more than the simple sum of the sensitivity of the systems in which they engage.

Finally, factors external to their communities will continue to influence their vulnerability; the most important are the institutional and market resources described in subsequent sections.

5.3.3 External resources for adaptation: institutions

External factors may influence the vulnerability of the communities being studied as much as the internal dynamics of their production systems. While the future role of institutions is difficult to predict, their current absence of readiness to manage climate change is a strong indicator. Key informant interviews indicated that the Rural Councils in the South have slightly less overall capacity than those in the North, yet these southern CRs have had more experience engaging in activities that address environmental and climate-related constraints to production. All in all, in light of the fact that these results were derived from single interviews with staff of these institutions, we do not consider this difference significant enough to be taken into consideration in our analysis.

Similarly, no significant differences in terms of preparedness to support adaptation were found in the level of capacity of the decentralized technical services interviewed. A summary of agricultural and livestock efforts undertaken in eastern Senegal presented in the Adaptation Options section below complements results described in section 4.3.3 above. A number of projects have been implemented in the study, most of them with a mix of livestock and agriculture elements. Their periods of implementation and target areas overlap to greater and lesser extents; a more intensive research effort would be necessary to measure the relative impact of these projects on the adaptive capacity of different livelihoods.

Key informant interviews found no significant differences in the readiness of the institutions studied to support climate adaptation by households of the three types of livelihoods studied. Literature does, however, indicate a lack of the following: state-supported means for transhumant and semi-transhumant

herders to gain pasture and water point tenure; national livestock policy and programs promoting the intensification of livestock production and its integration into agricultural systems; and clear national policy and programs supporting commercial agriculture. Livestock projects that have provided infrastructure and promoted tenure projects principally have targeted the Ferlo to the west of the study zone.[11]

5.3.4 External resources for adaptation: markets

Climate change can be expected to affect markets on two fronts: access and prices. Seasonal rains currently cause a dramatic decline in road quality annually; decreased rainfall may mitigate this effect. At the same time, an increased frequency of high-intensity rain events will more quickly wear down roads, especially those that have not been paved, and higher temperatures will speed the deterioration of paved roads. This assessment did not model these offsetting impacts of climate change on the different roadways of the study zone.

The impact of climate change on prices will be felt through decreased levels of production and greater unpredictability, which will weaken the effectiveness of markets in providing income and meeting needs for food and income in times of demand. A significant climate-driven decline in production at any scale — local, national, or international — will reduce the volume of available goods and result in higher prices, most particularly where substitutions or stocked quantities are not available. Any local increase in the price of essential commodities will strongly impact the households in these departments, who substantially rely on commodities from outside the area yet possess limited purchasing power.

This situation has already occurred. Despite the government's efforts to control prices, Senegal's rural poor were hard hit by spikes in the international market price of rice in the first decade of this century, resulting, at least in part, from climate shocks. While rural producers may occasionally profit from surplus and higher sale prices in years of crop failure elsewhere, the net dependence on essential foodstuffs from outside the household tilts the balance against them in the long run. As climate change makes production and prices less reliable, it also will decrease the effectiveness of market engagement as a livelihood strategy.

Nevertheless, withdrawal from the market will not be a viable strategy for these households unable to subsist on their own production. Planning across time is an important element in exploiting markets. This planning is perhaps most visible, and incurs the greatest risk, when households borrow on credit in anticipation of a successful harvest. Given the storage and mobility inherent to the current system of livestock-raising, these deteriorating conditions may impact livestock holders less than households that rely more on crop farming.

On the other hand, as the commercialization of animal husbandry increases, producers increasingly go into debt to purchase feed in the hope of keeping their animals alive until the rains begin. They, too, depend on efficient markets for inputs and sale of their produce. Unlike farmers, when extreme drought hits, they will face the choice of either losing all their productive capital or selling it off at low prices in saturated markets.

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[11] In the past decade, the government has made efforts to promote transhumant mobility, but these efforts have tended to be mitigated by conflicting policies that favor crop agriculture and intensive livestock production. This issue is, in part, a reflection of the fact that, despite renewed interest, transhumance-based livestock production still suffers from a lack of political support at most levels of government.

In all cases, households with significant alternative, non-climate based sources of income, such as the migration remittances of livestock-dependent households in the North or the off-farm employment of crop-dependent households in both sub-zones and mixed-system households in the South, will continue to use markets more successfully to decrease their vulnerability to climate change. Engaging in the market will remain a useful, yet much less predictable tool — one that is much more effective for households with enough assets to withstand market vagaries.

6.0 CONCLUSIONS REGARDING VULNERABILITY

The purpose of this assessment was to identify the various causes of climate change vulnerability of the households in the study zone. The following hypothesis drove this inquiry: *households with livelihoods that include livestock are less vulnerable to climate change than households whose livelihoods are primarily dependent on crop agriculture.*

The study team addressed three key questions:

- In the study zone, households of which of the three production systems being studied (crop-dominant, mixed, livestock-dominant) are most vulnerable to climate variability?
- How will the relative vulnerability of households that depend on each of the considered livelihood strategies change in the short term and in the long term?
- What key factors make households of the different livelihood strategies vulnerable?

6.1 CURRENT VULNERABILITY

Non-climate stressors: Households across the study zone face very serious non-climate challenges to their productive systems. For crop farming, these include an absence of sufficient means to redress the declining natural resource base, inadequate labor, and a lack of access to affordable fertilizer and other inputs. Limited access to pasture and water constrains livestock production; in the South, bush fire, deforestation, and increased farming of lowlands further reduce the supply of highly sought-after pasture. Both crop and livestock production systems face the constant threat of pests and diseases.

Institutions: Households receive little support from outside their communities to address these challenges. The decentralized local government institutions, the Rural Communities, have limited human capacity and few financial resources; they have yet to prove themselves to be a source of effective support to local farmers and herders. Projects and NGOs provide time-limited support to the specific communities in which they work; yet of the 15 villages studied, only 5 percent of households reported having received assistance or aid from these types of institutions, a proportion similar to that of those who report having received assistance from the local government. The supply of veterinary services, now privatized, provides a relative bright spot: 50 percent of households now report having access to a veterinarian, and 20 percent report having their animals vaccinated. At the same time, institutional lacuna regarding rangeland tenure, and the negligible capacity to address related conflict, may constitute the most important institutional gap for production in the zone.

Markets: Underdeveloped, hard to access, and inefficient markets decrease profits and dampen conditions for subsistence and commercial production for both crop and livestock production.

Climate stressors: Rainfall significantly affects yield potential across the study zone, with impacts that substantially vary by department and crop. Average annual rainfall in the North is lower than required to achieve the optimal growth range for cowpea, sorghum, millet, maize, and groundnut. The amplitude of variation in rainfall is also much higher in this part of the study zone, resulting in a greater inherent risk

to rain-fed agriculture. Because farmers in the North cultivate crops just above their climatic thresholds, a decline in rainfall in the North affects yields much more than a similar decline in the South would. Both the literature and simulations based on observational data indicate that cowpea, sorghum, and millet perform better under dry conditions than maize and groundnut do.

Local climate affects pasture available to herders less directly than it affects crops, because herders are able to move the source of their productivity and some feed supplements purchased on the market are not locally produced. Nevertheless, a comparison of differences between recent dry and wet years shows dramatic variation, especially in the departments of Matam and Bakel. On the whole, climatic variation in the past has affected biomass more than it has affected crop yields.

Agricultural portfolios: The three livelihood types, defined based on ratio of livestock held to land farmed, cultivate different proportions of crops and types of livestock. These varying proportions result in different levels of sensitivity to climate. The most striking differences in farmed crops reflect the results of crop yields under different climate regimes noted above; households in the North cultivate more cowpeas relative to other crops, while those in the South depend more on groundnuts and maize.

Regarding livestock, livestock-dependent households in the North hold a significantly larger proportion of their herd in small ruminants than do those in the South. This finding aligns with our understanding of the relative vulnerability of cattle to sheep and goats. Crop-dependent households that hold significantly fewer livestock, on the other hand, hold a larger proportion of their herds in cattle in the North, and a much greater proportion in goats in the South — equal in number to that of both cattle and sheep.

Households of the three studied livelihood types also strongly depend on migration and off-farm income sources. As compared to households that are more dependent on crop farming, a significantly larger percentage of livestock-dominant households and those with mixed systems receive more than 50 percent of their income from migration remittances. On the other hand, all crop-dependent households and mixed-system households in the North compensate for their relative lack of migration remittances by depending more on off-farm sources of income. These differences appear to balance each other out, with households of all livelihood types roughly equally dependent on agriculture.

Livelihood assets: Analysis of the broad set of household assets revealed little difference in overall wealth between the northern and southern sub-zones. In comparing livelihood systems, mixed-system households in the North proved the wealthiest category, followed by livestock-dependent households in the South. Crop-dependent households in the South scored the lowest. Measures of stressors on households and their productive systems mirror these results. The study team attributes this pattern, at least in part, to the capital-intensive nature of livestock raising; households with less income are simply less able to invest in livestock. In the North, wealthier houses spread risk in mixed systems. In the South, where agricultural diversity is less important, the wealthiest invest in livestock as a source of income. Households with the least capacity — those that predominantly cultivate crops and own less livestock — are less able to diversify and less able to invest in the increasingly cash-intensive animal husbandry sector.

6.2 LIVELIHOOD VULNERABILITY

Exposure: Most of the climate models project a reduction of annual rainfall averages to a level on the order of the one observed in the 1970-1990 period. As climate change is also expected to increase variability, the frequency of dry spells and exceptionally dry years may nevertheless be higher than in this historical period. While projecting an overall drying, different models project different levels of this drying across the study zone. Models also differ in the level — and even direction — of change between the northern and southern portions of the study area. In the southern portion, results also suggest a possible increase in rainfall earlier in the season. Projections additionally show a consistent increase in

maximum and minimum temperature across the whole study area, ranging from 2 °C to over 5 °C in selected months. The increase is consistently stronger in the North and for 2050.

Even when taking temperature into consideration, modeling the impact of these changes on crop performance suggests that declines in yields out to 2050 may be on the order of those experienced in the 1970s. Similar to that period, the impact can be expected to be greater in the North, where farmers growing crops do so in a climatic context much closer to crop thresholds.

Modeling the impact of projected changes in climate on biomass in the study zone indicates that, in all cases, the impact is most dramatic in the North, transitioning to less severe in the South. Results from different climate models show a range of effects, from declines to increases in biomass. In conjunction with the effect of climate change, continued growth of livestock populations in the North will very likely produce a deficit in natural pasture. If herders continue extensive or semi-extensive management practices, especially coupled with transhumance from the North, pressure will increase on the resources in the South, where focus group participants reported that tensions over these resources already exists.

If we compare these results, we see differences in the impact of climate on production systems in the North; in the past, climatic variation has affected biomass availability more strongly than it has affected crops. The limited modeling conducted for this assessment also indicates that climate change will decrease biomass more than it will affect crops. In the more humid South, the picture is less clear. Nevertheless, at least historically, climate variability appears to have had a stronger impact on biomass than on crops.

Sensitivity: Both observed and projected climate affects households more in the North than in the South, regardless of crop and livestock portfolios. Agricultural portfolios also more strongly affect sensitivity in the North than in the South. In particular, in the North, livestock-dependent livelihoods systematically score as more sensitive than crop-dependent and mixed-system livelihoods. In the South, although the differences are smaller and less consistent, within this sub-zone, crop-dependent households are less sensitive than livestock-dependent and mixed-system livelihoods. Income that households receive from non-farm sources has little impact on relative sensitivity, as households tend to compensate for deficits in one area (such as limited off-farm income among livestock-dependent households in the South) with strengths in another (higher rates of migration for that same group).

Livelihood vulnerability: The climate change vulnerability of the three livelihoods significantly varies between livelihoods and between the two sub-regions of the study. Analysis based on historical climate data indicates that crop-dominant and mixed systems have relatively similar levels of vulnerability across the two zones, yet for different reasons. Both are more exposed and more sensitive in the North, but both also have more adaptive capacity in that region. Overall, livestock-dependent households in the North are the most vulnerable and those in the South are the least vulnerable. The total scores for the other four categories are all relatively similar and fall between these two. Results based on potential changes in climate at the 2030 or 2050 horizons are not substantially different from these findings.

External factors may influence the vulnerability of the communities being studied as much as the internal dynamics of their production systems. Key informant interviews found no significant differences in the readiness of the studied institutions to support climate adaptation by households of the three types of studied livelihoods. Literature does, however, indicate a lack of the following: state-supported means for transhumant and semi-transhumant herders to gain pasture and water point tenure; national livestock policy and programs promoting the intensification of livestock production and its integration into agricultural systems; and clear national policy and programs supporting commercial agriculture. Livestock projects that have provided infrastructure and promoted tenure projects principally have targeted the Ferlo to the west of the study zone.

As climate change makes production and prices less reliable, it will also decrease the effectiveness of market engagement as a livelihood strategy. Given the storage and mobility inherent to the current system of livestock raising, these deteriorating conditions may affect livestock holders less than households that rely more on crop farming. This assessment focuses on changes in climate trends, as opposed to extremes, such as drought, which may have a much different impact on relative livelihood vulnerability. When extreme drought hits, livestock holders, unlike farmers, will face the choice of either losing all of their productive capital or selling it off at low prices in saturated markets.

Assessment hypothesis: The hypothesis that has driven this assessment is as follows: *Households with livelihoods that include livestock are less vulnerable to climate change than households whose livelihoods primarily depend on crop agriculture.*

The quantified results presented in this assessment lead to the conclusion that livestock dominated households in both the North and the South are more exposed and sensitive to climate change than households of other livelihood types. Nevertheless, while holding livestock may not itself be the cause, the hypothesis appears true in the southern portion of the study zone. Although the pasture relied upon in this sub-zone has been, and is likely to continue to be, more sensitive to climate variation and change relative to crop farming, households that depend on livestock have, on the whole, significantly greater resources to attenuate this vulnerability and currently experience significantly fewer signs of livelihood stress. It appears the wealthiest houses in the southern zone own and invest in livestock. From the perspective of these households, other factors may override the climate sensitivity of the pasture their animals they rely on. These considerations may include the risk management advantages provided by a diversified portfolio; the household's access to sufficient pasture of good quality in diverse locations; or the storage value of livestock, absent to other forms of savings or investment. Because of their wealth, in this sub-zone livestock-dependent households are less vulnerable to climate change than either mixed or crop-dependent households.

In the North, however, contrary to the hypothesis of this assessment, livestock-dependent households appear to be the most vulnerable. Climate strongly affects the quantity of available pasture with which they may feed their livestock. And, although this assessment was unable to model their reliance on pasture outside of the northern sub-zone, it did document trends that threaten continued access to this resource by these households. Focus group and key informant interviews, as well as land use mapping identify the following drivers of reduced pasture in the southern zone: bush fires, agricultural expansion, exploitation of lowlands, deforestation, fencing, and increased investment in livestock. Competition for the remaining resources has also provoked tensions that may result in conflict, and further restrict access. The pasture in the southern sub-zone that mitigates their vulnerability now is likely to be less available in the future.

The livestock dependent households in the North also have fewer resources to address climatic variation relative to the mixed system households, and, while their adaptive capacity is similar to that of crop-dominant households, it is more dependent on migration remittances, which focus group participants report have been declining in recent decades. As with the households in the South, it is unclear whether the sensitivity of livestock raising is the cause of their relative lack of wealth, or if an existing lack of wealth is the cause of an absence of investment in crop agriculture.

Caveats to these calculations have been detailed in the preceding chapters, yet it is clear that geography, and the availability of pasture, influence whether the hypothesis of this assessment is correct for a particular population. The assessment also highlights other factors, such as wealth, the composition of agricultural portfolios, non-agricultural sources of income, and gender, that influence the vulnerability of a household or person. The external context outside these communities also influences vulnerability. Markets and the efforts of governmental institutions, projects, and civil society certainly will affect the vulnerability pathways of the different livelihoods in this area of Senegal.

7.0 ADAPTATION OPTIONS

7.1 INTRODUCTION TO THIS CHAPTER

As the assessment team studied vulnerability, it also explored ways to address the vulnerabilities that were identified. Following the research framework, we identified and assessed the adaptive strategies available to households of the study zone. The team also explored and assessed the options for supporting these local adaptations through governance, research, and extension approaches. The principal methods the team employed to study these options were a literature review of historical responses to changes in climate, the focus group discussions in the study villages, and a review and evaluation of previous research and extension conducted in Senegal relative to agricultural adaptation to climate in the study zone.

GENDER AND COPING WITH DROUGHT

In times of drought, when food rationing was necessary, male household heads distributed the grain to be used in meals. They also became more directly engaged in gathering wild foodstuffs, another task otherwise left to women.

This chapter explores the results of all of these inquiries, while the following chapter covers the process of assessing and prioritizing these options; it also presents the final prioritized list.

7.2 LOCAL RESPONSE TO CHANGES IN CLIMATE

7.2.1 Local responses to changes in climate in the past

The focus group discussions conducted for this assessment provide insight into how men and women of the communities of the study zone have responded to climate variation and change during the past 20 years. Yet the worst rainfall conditions in these years were mild compared with the droughts of the 1960s and 1980s. In the periods 1968–1973 and 1983–1984, the people of the Sahel suffered severe droughts that provoked responses that

EXAMPLES OF FARM PRACTICES TO MANAGE CLIMATIC RISK*

- Moving cultivation to new lands in a different agro-ecological zone or at a different elevation
- Planting over a greater surface
- Staggering and sequencing planting dates to optimize production and labor efficiency
- Investing in water management and rainwater harvesting
- Irrigation
- Late planting for forage
- Changing seed to drought-resistant and locally adapted varieties
- Replanting with earlier maturing varieties

**See Annex P for citations of literature discussing these practices.*

transformed their societies. These droughts destroyed harvests and wiped out herds across northern Senegal. The suffering drew world-wide attention, and migration rates soared. The past two decades also have seen milder conditions than those projected for 15 and 35 years from now. The following review of the research literature provides an additional perspective regarding extreme events of the past.

The people of the communities of the study zone changed their agricultural practices in response to these events. In fact, many of the practices communities now employ to manage climatic risk became widespread following the droughts of these years. Farmers adopted new technologies for managing moisture and maintaining the health of soils. They shifted cultivation to lower, moister lands. They also diversified into less climate-dependent sources of income, such as crafts, trading, and gardening. They relied more on migration and migration remittances and less on the farm labor of the men who migrated.

For pastoralists, so long as the droughts were not severe, the impact on management practices was less radical; responsiveness to changes in climate plays a key role in their livelihood system. Seasonal and longer-term mobility always has been key to their productivity. Historically, pastoralists have stored wealth to draw upon in times of need, often more successfully than farmers. Building up surplus livestock for eventual sale was facilitated through the distribution of herds across different locations to the care of others, a practice that not only enables owners to accumulate more than can be supported by local water and pasture resources, but also disburses risk across institutional and climatic contexts.

Changes in climate affect different livelihoods in very different ways. The most severe of the droughts not only decimated crops but also delayed the regeneration of herds, as forage species and water points dried up. Given seed, farmers could plant in the following years, but herders who were unable relocate often lost their livelihoods. Indeed, responses to these droughts included a rise in "professional herders" who owned no livestock. Research also identifies cases in which bereft herders attempted to regain their livelihoods through rustling.

HERD MANAGEMENT PRACTICES FROM THE LITERATURE*

- Moving herds to resource-rich regions
- Moving herds greater distances
- Changing herd species composition, such as increasing the proportion of small ruminants
- Increasing commercialization, such as shifting to fattening, or shifting from milk to beef production
- Splitting single herds into multiple discrete herds
- Intensification and sedentarization of livestock production
- Managing sheep birthing so that lambs appear shortly after rains

**See Annex P for citations of literature discussing these practices.*

These examples from the past provide useful input regarding potential responses to climate change, yet they should be treated with caution. The context has changed in the past 30 years, most obviously through population growth. Nor can we predict how effective these responses will be under climatic conditions heretofore unseen, which include not only higher temperatures but also, in all likelihood, increased frequency of flooding, dry spells, and drought.

7.2.2 Recent responses to changes in climate

Focus group discussions revealed that rural producers in the study zone continue to employ some of the same strategies and management practices identified in the literature as responses to changes in climate during the 1970s and 1980s. They also identified practices research describes in other regions of Senegal and the Sahel. The practices described in the focus groups include both changes in field practices, "Agricultural Innovations," and household-level strategies that can be grouped into five categories proposed by Agrawal (2011).

- **Agricultural innovation:** developing or adopting new practices, technologies, or management strategies to manage production risk while maintaining or increasing productivity.
- **Mobility:** shifting the location of productive assets, such as family labor, herds, or crops.
- **Storage:** accumulating assets, such as livestock, food, or money, to draw on during gaps in production.
- **Communal pooling:** investing in jointly held resources, such as stewardship of natural resources, or social networks and institutions.
- **Markets:** using exchange as a potential source of asset accumulation, as well as for acquiring diverse goods in times of need.
- **Diversification:** investing in productive activities with different sources of risk, such as planting multiple crops or adding livestock-raising to a household's portfolio.

Strategies employed by households of the study zone:

Agricultural Innovation:

- **Farming new crops**: Farmers have changed what they farm, opting for crops and varieties that are better adapted to new conditions. In the southern portion of the study zone, farmers in one of the survey villages now plant a variety of maize that they can grow in the receding waters of seasonal pools (bas-fonds). On uplands, to cope with shorter seasons and more erratic rainfall patterns, villagers plant less of certain varieties of millet and sorghum. In many cases, sorghum planting has been reduced in favor of planting millet, which is less subject to attack by birds and insects as well as better adapted to shorter rainy seasons. Some villagers have discontinued farming indigo. Newly added crops — okra, watermelon, and squash — reflect both an adaptation to new rainfall patterns and an increased intent to market crops.
- **Farming more land:** To maintain or increase production in good years and increase the likelihood of some harvest in poor years, farmers also have expanded the surface area they cultivate. They have done this most aggressively through the use of animal traction. Fourteen percent of the households in the North and almost one third of the households in the South report farming more land now than they did 20 years ago. Focus group participants noted that they recognize that this practice has contributed to deforestation, reduced the duration of the fallow periods, and sped the decline of their soils.
- **Feeding livestock differently**: With the lack of dry season pastures in the northern sub-zone and reduced availability of preferred pasture species across the study zone, herds spend shorter periods in the fields around their owner's village and more time traveling greater distances. Wealthier owners hire professional herders and send their herds to Mali. Livestock owners also increasingly depend on purchased supplemental feed and "cut and carry" fodder — grasses, crop residue, or leaves — transported to stationary herds.

- **Raising new species**: Villagers across the study zone reported increased attention to breeding and the crossing of "sedentary" cattle types with "transhumant" cattle, resulting in more climate and disease resistant cattle as well as an increase in beef production and a reduction in milk production. (Livestock experts consulted for this assessment, however, noted that cross breeds produced in this manner withstand transhumance worse than traditional breeds do.) Villagers also have responded to decreases in crop residue and pasture by increasing the proportion of easier-to-feed small ruminants in their herds. In the South, farmers have begun raising livestock where they have not done so before.
- **Natural resource management efforts**: Focus group discussions did not uncover diverse and widespread efforts to improve the status of natural resources. Participants in the South respond strongly to the deforestation around them. As noted above, in the southern sub-zone, villagers reported having organized to maintain forest resources, although no specific examples were presented. Farmers also reported increased use of manure on fields.

Mobility:

- Men and women of the study have shifted fields to lands closer to water. This shift in location was accompanied by changes in crops, market orientation, and other factors. Across the study zone, women have begun farming vegetables in lowlands or close to wells.
- Herders have continued to move their livestock seasonally. The herds from the North of the study zone are moved south during the dry season. In the South, larger herds are moved to greater and greater distances from villages.
- The communities of the study zone also bear the burden of the use of this strategy by others. Herds from greater distances, such as from Mauritania and Mali, have begun to visit the South study zone for pasture in dry season.
- Men have continued to migrate seasonally, for short periods, for long periods, and permanently. They travel to destinations within the country, as well as to other countries. While the survey did not query migration destinations, the focus group responses suggest that Europe and the United States are more common destinations in the northern sub-zone, while urban centers in Senegal and the gold mines of Kédougou are more common in the South.

Storage:

- People increasingly see livestock as a form of investment and a form of capital to be sold in times of need. Migration remittances, in particular, are invested in animals.
- Community members do not describe the most visible investments in agriculture — traction animals, plows, and seeders — as a means of storing wealth, but as a way of increasing production. Land is not purchased in the study zone, and participants were not queried concerning investments in urban real estate, which do occur elsewhere in Senegal.
- Of the survey households, about one-fourth have at least one person who has recently participated in a savings group.

Communal pooling:

- Members of the villages in the southern sub-zone report having organized to maintain forest resources, though no specific examples of this activity were collected.

- Producers organize into farmers' and livestock associations to pool resources and manage natural resources.

Markets:

- Trade provides an important service for community members of the study zone, both facilitating the sale of produce and as a source of food during production deficits.
- Farmers have also begun using the market as a source of loans, entering into agreements with traders to sell their produce exclusively to them in exchange for cash loans.
- Women report having taken up market gardening as both a way to produce food off-season, and to increase incomes.

Diversification:

- As reported by focus group participants, the most evident form of diversification within agriculture has been the increasing investment in livestock rearing in the southern portion of the study zone.
- Women's establishment of gardens is also a form of diversification within agriculture.
- Participants also report increased efforts to generate other, non-climate-affected sources of income, principally through migration. Over half of the households have at least one member who gains an income from an activity that is neither agricultural nor based on migration, such as a craft, skilled or non-skilled labor, or a salaried job.

7.2.3 Options derived from local adaptive responses in the study zone

A review of the list of adaptive strategies above, in conjunction with the results of the vulnerability assessment, produces a list of trends that can be expected to be reinforced by the relative exposure, sensitivity, and adaptive capacity of the livelihood types in the two sub-zones of the study. Assumptions based on this study as well as research conducted elsewhere in the Sahel underpin this analysis of trends. The first assumption is that, across the study zone, demand for and use of farm land and pasture will continue to rise, despite the fact that the climatic risks inherent in exploiting these resources are also likely to increase. The second assumption is that the trend towards the concentration of livestock ownership reported in focus groups will continue: Over the past 30 years, larger herds are increasingly held by fewer owners. The third is that the success of local residents in finding less climate-sensitive sources of income, such as migration, will continue to (paradoxically) increase investment and commercial transactions in agriculture, including livestock. Finally, poorer farmers will seek to adapt to changes in climate through low-labor, low-cost remedies, such as expanding to new types of land, changing proportions of crops farmed, and experimenting with new crop varieties.

The identified trends:

In the North:

- Crop-dependent households are the least vulnerable and can be expected to continue to rely on cultivating crops. Nevertheless, given the results of the crop modeling exercise, the continued cultivation of maize and groundnut — which are already marginal crops and are likely to decrease in viability — over the long term appears unlikely, despite governmental support for the cash-earning groundnut and the possibility of new, hardier varieties.
- For households with the resources to do so, the strongest strategy to manage agricultural risk is often to produce a wide range of products to consume, store, and sell, creating a more diversified

relationship to climate and markets. Given the success of their diversified approach, the relatively wealthier mixed-system households in the North are likely to continue to invest in both crop agriculture and livestock. However, because of the greater relative exposure of pasture, they may also lead a broader trend towards smaller animals and greater dependence on fodder.

- The past 20 years have seen a concentration of cattle into larger herds that move greater distances. At the same time, focus group participants report that climatic conditions have reduced both the quantity and quality of pasture, with several valued species no longer found. As a result, herders who currently depend on mobility may become more dependent on it, increasing transhumance to the southern sub-zone.
- Although as a group they receive substantial remittances, livestock-dependent households in the North scored as most sensitive and most vulnerable across the study zone. Pressure will increase for the poorest of this group to hire out as herders to owners of larger herds and wealthier households whose labor supply has been reduced through migration.

In the South:

- In the southern sub-zone, it is likely that households with more cash will continue to invest in the less exposed livestock sector. This will not only reduce pasture available to herds descending from the North, but also shrink the supply of crop residue and reduce the demand for manure from the cattle of passing herders.
- Pasture will also decrease as poor precipitation and other factors degrade natural resources and reduce yields, increasing the pressure on farmers to expand fields into marginal areas and to increase lowland farming and market gardens.
- The role of capital, markets and cash crops will continue to play an increasingly important role in local production systems. During the past 20 years, farmers have increasingly purchased farm implements, and wealthy farmers have fenced their fields. Women have increasingly grown market vegetables.
- Reduced pasture will oblige local livestock owners to purchase fodder and send herds greater distances from their villages. For all livestock holders, well-functioning markets for fodder will become increasingly important.

7.2.4 The gender impact of identified local trends and adaptive strategies

The trends described above will not impact members of individual households equally. While not measured in this assessment, adaptive strategies associated with climate change may affect women differently than men. The following list draws on research conducted elsewhere in the Sahel, as well as the findings of the vulnerability assessment, to describe the likely impact of the trends and strategies described above on women in the study zone:

Because women are in charge of collecting fuelwood and water for domestic use, they will bear the brunt of climate's impact on the availability these natural resources, as described in this assessment.

Due to their weaker land rights, women tend to farm more marginal fields, with less healthy soils that support crop growth poorly when rainfall is inadequate or temperatures rise too high; women's crop farming will likely be more sensitive than the averages projected.

Lack of property rights may also impact women's control over a burgeoning form of adaptation, the increasing importance of market gardening. Male control over this subsector of agriculture may increase as it grows as a means of producing food and income in a more climate sensitive manner.

As harsher climates reinforce a transition from traditional pastoralist systems to more commercial systems based on producing beef for sale, the consequent reduction in the dairy value chain will cause women to lose this income source, one they have dominated historically.

A variety of factors, including lack of education, limit women's ability to migrate, which has proven to be a significant element of adaptive capacity in the study zone.

With weaker political voice both within their communities and among the external institutional resources, women will find it more difficult than men to advocate for support in adapting to changing conditions.

This assessment did not focus explicitly on gender issues; the unit of analysis of this study is the household. Nevertheless, as the observations above indicate, climate change will impact different members of households differently. The needs articulated by local governments and discussed below do not specifically address the concerns of women. Further research would be required to detail a full set of gender-specific findings and options. We nevertheless propose the adoption of one activity derived from the research of this assessment. Results of the focus group and household survey indicate that women, as well as poorer households, depend on raising poultry to provide food and income. The study also found that households report a higher rate of contact with veterinarians in the study zone than other types of external support. This strength could be built upon through the provision of vaccinations against the Newcastle virus, a disease that cripples poultry production and for which relatively inexpensive vaccines exist.

7.3 RESEARCH AND EXTENSION OPTIONS SUPPORTING LOCAL ADAPTATION

While many of the trends presented above suggest clear needs at the local level, they do not offer simple solutions. Not all of the trends described above should or could be supported. Almost all raise questions of governance and equity. Further analysis of the means for reducing climate change vulnerability in the study zone requires an understanding of efforts that have been undertaken in the past, the expressed needs of the communities in question, and the potential for these needs to be addressed. To answer these questions and analyze this potential, this assessment has focused on the government's research and extension services, locally elected governments, and markets. These have the potential to play an important role in addressing the vulnerability of households so dependent on the climate in Eastern Senegal. Annex L contains the complete report upon which the contents of this section are based.[12]

[12] While the final list of options does not include this specific recommendation, reinforcing veterinary services is included in the final list of recommended options, although it does not specifically reference poultry.

7.3.1 Summary of relevant development efforts

The government of Senegal and its development partners implement a large number of policies and projects supporting rainfed crop agriculture and livestock husbandry in the country. The following paragraphs focus on themes identified in Senegal's Second National Communication to the UN Framework Convention on Climate Change (UNFCCC). As such, they summarize recent and ongoing government efforts to improve rangeland management; promote the integration of livestock-raising and farming; increase access to new crop varieties; and improve natural resource management. To the extent possible they focus on projects implemented in the regions of Matam and Tambacounda, if not exclusively in the study zone itself.

National Livestock Development Plan for 2012-2016 (PNDE 2) represents a modernization approach through its focus on, among other measures, boosting production, improving marketable livestock products, and implementing a system of livestock insurance. The PNDE 2 strategy, like some of the livestock projects discussed below, also focuses on building or rehabilitating livestock infrastructure such as improved wells, boreholes, vaccination centers, and micro-dairy facilities. The PNDE and most livestock projects also emphasize producers' organizations, which increasingly play an important role in marketing, extension, and even, in some cases, policy formulation.

Improving rangeland management: CSE uses Normalized Difference Vegetation Index imagery to monitor the production of biomass in the rangelands and develop recommendations for both the ministries and herders. Management plans also have been developed for rangelands in the southern portion of the study zone, and projects such as PROGEDE have promoted demonstrations of agroforestry practices that contribute both to farm soil fertility and to livestock fodder. Attempts also have been made to delimit fixed corridors, largely to limit conflict between farmers and herders; so far, these attempts have met with limited success. To the west, in the Ferlo, projects such as the Livestock Support Project (Projet d'Appui à l'Elevage, PAPEL) have supported the shift toward sedentarization by supporting management of natural resources by herder associations in specific locations. Efforts also have been made to identify complementary sets of plants, including trees, for assisted rangeland reforestation.

Promoting integration of livestock raising and farming: The integration of livestock into farming constitutes wholesale system transformation. At the core of these necessary technical, cultural, and institutional changes is the transition from grazing to feeding. The advisability of phasing out grazing and promoting the local purchase and production of livestock feed and fodder continues to be debated. In Senegal, studies have been conducted on the potential benefit most often cited: the increased availability of organic fertilizer. A significant amount of research also has gone into developing industrially produced feed, assessing different types of crop residue, and evaluating potential forage crops. Yet, the principal constraint to extending these technical recommendations is not only the challenge of making livestock producers aware of these options, but also the scale of the necessary transformation and the integrated web of factors that would need to come about for the change to take place.

Increasing access to new crop varieties: Given the climate in Senegal, significant effort has been put into developing varieties adapted to limited rainfall. The state has developed technical guidance for the use of these varieties, many of which are adapted to the sub-zones of this assessment. Although the groundnut varieties that have been developed for the lowest rainfall regimes have not been extended to Matam and Kanel, other varieties adapted to more rainfall have been extended and adopted in Bakel and Goudiry. Millet Souna 3 was used in the modeling for this assessment and is the variety mentioned most often by the focus groups, both North and South. The sorghum hybrids that have been developed have not been promoted in Senegal, because the crop's alleopathic characteristics inhibit the growth of successor crops in the same field and thus exclude it from use in rotation. (This finding accounts for the general shift away from its cultivation noted in the focus groups for this assessment, as rainfall has fallen

under the thresholds of traditional varieties.) Research on cowpeas has focused on both adaptation to dryer climate and resistance to parasites, and a number of new varieties have been developed and widely adopted. New varieties continue to be developed; in 2013 the West African Agricultural Productivity Program announced the successful development of new sorghum and millet varieties. However, despite these advances in the creation of new varieties, extension and adoption remain constraints. In Senegal, only about 15 percent of planted grains and legumes are purchased; less than 10 percent are certified. The vast majority remaining comes from previous harvests.

Improving natural resource management:

- **Water management**: An estimated 15 billion cubic meters of unused rainwater flows to the sea from Senegal. Investment and research on ways to capture this resource for agriculture has been dominated by a focus on irrigation. Since the droughts of the late 1960s, both private and public investment to make greater use of the water of Senegal's rivers has increased significantly. In particular, the dams of Manatali and Diama along the Senegal River have enabled both controlled recession and irrigated farming. Since 2000, projects have constructed water retention ponds, one of which is in Matam. Regarding groundwater, while resources of quality and quantity exist, more research is necessary to determine its efficient and economic use. Agronomic research regarding water management has been focused on decision-support tools to inform the management of irrigated agriculture, including modeling the relationship between varieties, water regimes, and other inputs.
- **Soil conservation and restoration**: A number of practices to decrease erosion and increase water availability to crops have been studied and extended. Methods for which technical guidance has been developed and extended include embankments, stone barriers, live fences, and weirs. For increasing soil fertility and structure, guidance has been provided on dosage of organic manure, economic use of fertilizers, and the use of specific field trees. The use of wind-breaks surrounding irrigated fields also has been studied.
- **Forest resources management**: To strengthen forest management, CSE produces annual reports on forest health developed through the use of satellite imagery; some of these reports and resources have been used in this assessment.
- **National harvest forecasting**: Senegal currently uses a system of forecasting yields and monitoring crop quality, developed in conjunction with AGRHYMET and based on satellite imagery and crop modeling, to provide decision makers with early warning of potential shortages and to plan national management of harvests.

7.3.2 Research and extension options

While needs can be imputed from the actions households have engaged in to address changes climate described at the beginning of this chapter, the expressed needs of these communities also provide a useful perspective. The communities of the study zone have presented their desires formally, through local development plans. The assessment team used the review of the development context, summarized above, as a principal element in evaluating local development plans of the communities of the study zone. The needs expressed in these local planning documents were evaluated against past and ongoing extension and research efforts to identify activities that have been successful in the past, coincide with the policy and capacity of the relevant institutions, and address the climate vulnerabilities in the study zone. This analysis, conducted with the national agricultural research agency ISRA, constituted an important step in shaping diverse local responses to climate into pathways that can speak to national decision makers.

TABLE 19: LIST OF RESEARCH NEEDS BASED ON REVIEW OF LOCAL DEVELOPMENT PLANS, WITH PROPOSED RESEARCH

Sector	Constraint to be Addressed	Research Activity	Zone
Agriculture	Low sorghum yields	Identify and reintroduce photosensitive sorghum varieties that are better adapted to projected rainfall conditions.	Matam, Kanel
	Decreased utility of sorghum in crop rotation	Enable growing sorghum in rotation with other crops by identifying a sorghum variety with improved alleopathic characteristics. (Sorghum leaves a "residue" in the soil that is harmful to other crops, as well as certain weeds.) Farm management, such as tillage practices, also can affect crop alleopathy.	Study zone
	Low grain yields	Research millet, sorghum, and maize varieties with high yield potential.	Goudiry
	Soil fertility	Extend selected proven practices, such as the application of the Urea Deep Placement practice (now used with irrigated rice), to maize, upland rice, and sorghum.	Study zone
Livestock	Poor quality and quantity of forage	Identify high-yield forage varieties (both annual and perennial) that can out-compete weeds.	Matam, Kanel
	Novelty of fixed livestock raising	Conduct cost/benefit analysis of the prospects for sustainable adoption of new practices, such as animal fattening, mixed organic/inorganic fertilization, covered manure piles, etc.	Goudiry
		Develop technical guidance to help farmers optimize cash/nutrient trade-offs between on-farm biomass (crop residue, manure) and purchased biomass (groundnut hay, feed).	Study zone
General	Climatic uncertainty	Improve forecasting of climate change relevant to agriculture through weather and climate modeling.	Study zone

TABLE 20: LIST OF EXTENSION NEEDS BASED ON REVIEW OF LOCAL DEVELOPMENT PLANS, WITH PROPOSED TECHNOLOGY

Sector	Constraint to be Addressed	Technology to be Extended	Target Zones	Concerned Groups
Agriculture	Degradation of soils	Conservation agriculture	Goudiry, Bakel	Small cereal producers
		Sustainable fertilizer practices	Study zone	Farmers
	Declining productivity	Improved community seed banks	Study zone	Farmer associations
	Limited crop and variety options	Improved varieties and new crops	Study zone	Farmers
	Dependence on one production system	Integrated mixed livestock/farming systems	Bakel, Goudiry	Farmers
	Uncertainty	Improved climate and early warning services	Study zone	Rural Communities, Community Organizations
Livestock	Declining availability of pasture	Improved management of livestock corridors through fire prevention, replanting of forage species, and controlled grazing	Matam, Kanel	Livestock producers; farmers, community-based organizations
		Commercial supplemental feed, especially important under emergency conditions	Study zone	Livestock associations
		Forage crops	Study zone	Farmers
		Approaches to create and maintain grazing reserves	Study zone	Livestock producers

Natural Resources	Unexploited rain water	Water management structures, such as retention ponds	Study zone	Farmers, local communities
	Low moisture	Water management practices, such as *demi-lunes*	Bakel, Goudiry	Farmers
	Soil degradation	Anti-erosion practices such as windbreaks and live fences	Bakel, Goudiry	Farmers
	Deforestation	Community and private forest production of timber and firewood for commercial sale	Bakel, Goudiry	Rural Communities
		Agroforestry	Bakel, Goudiry	Farmers
		Public forest management and planned exploitation of resources, such as wood for charcoal	Bakel, Goudiry	Rural Communities
		Environmental education	Study zone	Youth groups

The research and extension activities presented in the above tables are not new; they have been experimented with elsewhere in the Sahel, if not in Senegal. Through this experience, however, the Government of Senegal and its partners have become aware of the implementation challenges involved. Senegal has grappled with many barriers standing in the way of extending technologies that have been researched and developed. Long-term planning, political will, and significant and long-term funding are required to scale targeted research for generalized adoption and then to demonstrate and promote it. Human capacity constraints also must be overcome; staff require not only technical training, but also education in communication methods.

On the receiving end of the process, participants in the value chain lack organization and a professional approach. Producers themselves have a low level of education. To overcome these barriers, the quality and sustainability of national agricultural research, extension, and advisory support must be improved, as well as the capacity of producer organizations and private operators. Local governments need to be able to facilitate collaboration between producer organizations and local farmers, and research and extension practices must be made more participatory. The national government's hand in monitoring and coordinating the implementation of programs also needs to be strengthened.

Requirements for the success of these recommendations go beyond improving the research and extension system. Their sustained adoption will also depend on changes in local governance and markets. To take a clear case, institutional changes play a particularly important role in the sets of recommendations above that depend on improved tenure for crop farmers and herders. Such change would be necessary, for example, to create grazing reserves as a means of addressing a principal climate-related stressor in the southern portion of the study zone: increased pressure on pasture resources. Creating grazing reserves would require the transformation of portions of livestock corridors into managed pasture. Complementary activities from the table above include seeding to regenerate forage on these reserves, and defining corridor limits by communities through such methods as anti-erosion hedges of various forage species. To be effective, the effort also would also require community brush fire management. Improved management of the harvesting of wood in these areas also would be necessary in the long run.

Such activities targeting improved resource tenure have been undertaken in the study zone. Rangeland management plans have been developed in the departments of Goudiry and Bakel. Elsewhere in Senegal, primarily in the Ferlo to the west, projects have supported herder association management of natural resources, and attempts have been made to delimit fixed corridors. Plants, including trees, have been identified and extended for assisted rangeland reforestation. Yet, while measures for clarifying tenure and improving pasture quality and quantity respond to concerns articulated in focus groups, villages do not report having undertaken them, as adaptive practices or otherwise. Many of the government's previous efforts along these lines have had limited success, in part because they address these difficult resource tenure issues.

For example, focus group participants did not report seeding pastures or pooling community resources to manage livestock corridors; this contrasts with their acceptance of crop management adaptive practices. Successful adoption of these rangeland practices requires changes at the institutional level, which, in turn, requires external support and collaboration with local communities. For these recommendations to be successfully and sustainably adopted, the governance issues facing local institutions, as well as those related to the effective diffusion of technologies and the capacity of markets, would have to be addressed. Some of these challenges are discussed below.

7.4 OPTIONS TO SUPPORT LOCAL INSTITUTIONS

As made clear by this assessment, the external institutions with a mandate to support the study villages face a broad spectrum of constraints. As a result, recommendations to support these institutions, coincide with recommendations to strengthen their capacity in more general ways as well. This particularly holds true for the local governance institutions. Here, we have selected those recommendations that would most directly address climate vulnerability and improve institutional readiness. They would do so by creating or strengthening local institutional capacity to manage information and knowledge to assess and prioritize climate risks; improve planning to strengthen flexibility and innovation in the face of climate trends and shocks; increase capacity to be responsive to evolving community needs through greater participation; and strengthen accountability and redress power imbalances. See Annex G for a more complete discussion of these recommendations:

- Support continued partnering of projects with local government and NGO actors, building on their understanding and awareness of the local context while increasing the sustainability of their activities. Projects, as external actors, could provide resources to support responsiveness to evolving local needs by facilitating participation in decision making from diverse sections of the communities and supporting the systems that address these expressed needs through specific policies and activities.
- Strengthen the Community Assistant position. If the government is committed to decentralization, recognize that the process will take a long time and that local capacity is critical. This capacity may include greater job security and training. Specific capacities to build include: the capacity to access, use, and distribute climate information; the capacity to use planning tools appropriate to climate variability and threats; and the capacity to record and learn from previous adaptation efforts.
- Work with the government to incorporate climate change awareness and programming in the next iteration of key documents articulating and guiding local development, the Local Development Plans. This work will support local adaptive responses as well as strengthen coordination on adaptation with technical services and project staff. In addition to more concrete updates for local conditions, revised Local Development Plans should identify resources to respond to climate variability and shocks. These plans also should be developed with an awareness of, and to potentially prepare for, the expected long-term changes in climate.
- Support the departments of the study zone to better plan for the cross-sectoral threats of climate change by strengthening the integration of technical input from across sectors in the development and implementation of local development plans.[13]

Due to the large number of options produced through this assessment, and the focus of the assessment on food security, and more generally on agriculture, the detail of this set of recommendations was not carried forward for further analysis during the process described in chapter 8 below. These recommendations were grouped under the broader option, "Raise awareness and capacity of rural communities regarding climate change and disaster management." It should be noted, however, that this option was prioritized above all others in the final analysis described below.

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[13] One possible source of lessons on addressing these challenges may be the Agence Francaise de Developpement project: Appui à la décentralisation et au développement local dans les Départements de Vélingara, Tambacounda et Bakel (ADDEL) which is working at the departmental level to improve access to services and increase local participation in the creation and implementation of development plans in conjunction with local authorities.

7.5 OPTIONS REGARDING TRANSPORTATION AND MARKETING

Despite their physical and institutional limitations, markets play a critical role in the adaptation strategies of the households of the study zone. While the assessment was unable to model changes in rates of deterioration attributable to future climates, the evaluation did map a road network of limited functionality as well as describe some of the economic and organizational constraints that exacerbate these physical constraints. Fewer roads service the less populated southern portion of the study zone, and those that do are of poorer quality and connect a less dense network of markets.

Yet across the entire study zone, virtually any measure that improves market access and efficiency can strengthen the capacity of households to adapt to climate change. Measures should be geared to bolster commercial production, increase market efficiencies, reduce transaction costs, and strengthen local purchasing power. Such actions include efforts to strengthen the local capacity to process, store, and distribute farm and livestock produce, and include improvements in the density and condition of road networks. They also include professionalizing value chains from rural production to urban consumption or export. Improved dissemination of market information may be one of the most cost efficient and effective contributions; it could also help level the playing field between isolated poorer producers and more mobile and connected wealthier ones.

There also is a potential role for national trade policy regarding the importation of low-cost subsidized products that compete with local products. If successful, such measures to improve the access of local producers to efficient markets may reduce risk by increasing capacity to generate and store income. However, they may also increase market engagement and should be accompanied by measures to mitigate the accompanying market risk, such as forms of insurance and contracts.

Other than the option, “Establish instruments for crop and livestock insurance," these recommendations were not carried forward for further analysis. USAID indicated that investment in improved roads falls outside of its expected strategic planning for this part of the country. Further, improved productive capacity would be a prerequisite for a market based value chain approach to be effective in this area where the vast majority of agricultural production is currently directed, by necessity, to subsistence needs.

8.0 ANALYSIS OF OPTIONS

8.1 INTRODUCTION TO THIS CHAPTER

The adaptation options presented above cover diverse domains: agricultural research, extension and technical advice, local government capacity building, and infrastructure investment. The selection among these options engages questions of government policy and the strategic plans of multiple donors; it requires broad consultation and concerted decision making. To begin this decision making process and produce this study's recommendations, the ARCC team engaged in a multi-step process of presentation, discussion, validation and prioritization. First, the extended team conducted a workshop to validate and review the options listed in the previous chapter. The team then presented and discussed the list of options produced in a validation workshop with key persons in the study zone. The feedback from this workshop was incorporated into a list then presented to national level stakeholders in Dakar. In this meeting, after presenting the assessment, the team conducted a Multi-Criteria Analysis of options. In conjunction with these activities, ARCC also submitted the assessment to USAID/DC and USAID/Senegal for input at various stages in the process of developing the final report.

8.2 DETERMINING THE OPTIONS TO BE PRIORITIZED IN THE NATIONAL LEVEL WORKSHOP

Representatives of the local partner institutions ISRA and CSE joined the ARCC assessment leader, the ARCC Climatologist, and the coordinator of the assessment fieldwork in the validation workshop held in Dakar June of 2014. During this workshop, the team shared and discussed the study and reviewed, refined and validated a final list of options. The agenda of the workshop and the working group findings can be found in Annex AA, "Validation Meeting and Study Zone Presentation Products." Shortly thereafter, the team shared the results of this meeting with USAID/Senegal. (The PowerPoint slides used in this presentation can be found in Annex BB, "Initial Presentation of Results to USAID Senegal.")

On June 23 and 25, a reduced team presented the results of the assessment in the towns of Ourossogui and Bakel. Approximately 20 persons joined the team for each event. The majority of local participants came from government technical services, but each of the two meetings also included a few representatives from projects, NGOs, and Rural Councils. Each half-day meeting consisted of a brief presentation of the assessment and results, followed by a guided discussion concerning the results and recommendations.

Participants of the two meetings generally supported the conclusions of the study and the options resulting from the validation meeting. In particular, they supported the options addressing the lack of seed of sufficient quality and quantity, the need for fodder crops, improved animal health services, improving the climate awareness of farmers, and building local government capacity. In both meetings, early warning systems were added to the list of options. Local participants also noted threats less obviously linked to climate change. For example, in both presentations, participants brought up the serious impact grain- eating birds have on yields. (The recommendations from participants are included in Annex CC "Study Zone Discussion Products.")

The assessment team leader then reviewed the recommendations from these various meetings, reviewed them against the assessment above and Senegal's National Adaptation Plan of Action, and from

them drafted a list of options to be considered in the national level presentation and multi-criteria analysis. The draft was shared with the research team, revisions were made, and the list finalized.

8.3 PRESENTATION TO NATIONAL STAKEHOLDERS IN DAKAR AND MULTI-CRITERIA ANALYSIS OF OPTIONS

On September 15, 2014, USAID hosted the USAID/Senegal Eastern Senegal Climate Change Vulnerability Assessment Presentation of Results meeting in Dakar. The objectives of the event were to

- Generate awareness of the issues and potential implications of climate change on livelihoods in Eastern Senegal.
- Improve understanding of constraints and opportunities for addressing climate change adaptation in Senegal.
- Discuss potential adaptation strategies and prioritize recommendations.

Forty-one people attended the morning plenary sessions of the meeting dedicated to presentations and discussion of the assessment. A third of the participants came from government agencies, the rest were distributed relatively equally among donors, NGOs, universities, and the private sector. (Annex W presents the agenda to this meeting, and Annex Z presents the exit survey and a summary of the survey results.) In the afternoon, a subset of 24 of the original participants engaged in a multi-criteria analysis (MCA) exercise. The results are presented in Table 21 below. The first and third columns present the results of the MCA, while the second and fourth present the results of a quick evaluation conducted prior to the MCA. The options are presented according to the average MCA scores, from highest to lowest score.

TABLE 21: RESULTS OF THE MULTI-CRITERIA ANALYSIS

OPTIONS TO SUPPORT ADAPTATION	MCA Avg.	Survey Avg. Rescaled	MCA Ranking	Survey Ranking
Raise awareness and capacity of rural communities regarding climate change and disaster management	3.9	2.5	1	11
Strengthen national climate and early warning information system	3.6	2.7	2	6
Strengthen systems to increase producer access to diverse and high quality seeds	3.6	2.6	3	10
Promote the integration of livestock raising in crop agriculture systems	3.5	2.5	4	12
Promote small and micro irrigation	3.4	2.6	5	9
Invest in research for climate-adapted crop varieties	3.3	2.3	6	13
Promote market gardening and production of niche crops, like bee keeping	3.3	2.7	7	7
Promote field practices to strengthen the management of runoff water	3.3	2.8	8	5
Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest.	3.2	3.3	10	2
Promote techniques to increase fodder production and collection	3.2	2.9	9	4
Reinforce veterinary services	3.1	2.7	11	8
Clarify tenure rights in livestock corridors and pasture	2.8	3.3	12	3
Establish instruments for crop and livestock insurance	2.8	3.6	13	1

Comparison with a brief survey of participants to evaluate the options prior to the MCA discussions suggests that the MCA results were the product of deliberation. The column "Survey Ranking" in Table 21 above, which presents the pre-MCA ranking, demonstrates that the process significantly changed participant opinions. For this survey each of the morning participants ranked the options as "very good, good, or least good." While for the MCA ranking, small groups of participants scored each option as: adaptive, robust, equitable, feasible, or efficient. This deliberation produced very different results. In fact, the option ranked 11th prior to the MCA activity was ranked first by the groups, and the option initially ranked first, was ranked last by the three groups. (The materials for the MCA activity, and the results can be found in Annex Y, "National Stakeholder Event MCA Instructions and Results".)

In discussion of MCA results, selected participants noted that the insurance option (11) and small and micro irrigation (8) choices would have scored more highly, except they scored very low on feasibility. Others stated that members were surprised that, in a context of potential decreasing rainfall, options related to water management received such low scores. These are options 1, 8, and 9, which were ranked 7, 5, and 8 respectively.) Participants also added conditions on some of their scores. For example, they scored increasing accessibility of quality seeds (2) very high, but note that they should be short cycle multi-purpose seeds that provide for both food and forage, and that they ranked early warning system (5) second, but that such a system needs to be accompanied by a complementary rapid response system. To these observations we also add that the option ranked most highly, "Raise awareness and capacity of rural communities regarding climate change and disaster management" may have received highest scores in part because of the broad nature of the recommendation compared with the other options.[14] We also note that options for strengthening livestock systems generally scored lowest. This was not commented on in the plenary discussion.

8.4 CONCLUSION TO THE SENEGAL VULNERABILITY ASSESSMENT OPTIONS ANALYSIS

The options for reducing climate change vulnerability in the study zone recommended by this assessment will have to be implemented in a region of Senegal beset by a host of non-climate stressors. The households of Eastern Senegal face enormous challenges to improving their condition. Rural producers work in an area virtually void of public infrastructure. Markets are hard to access, and they function poorly. Local governments receive limited support from the national government and are poorly understood and under resourced. The natural resources on hand to overcome these constraints consist of limited lands, depleted soils, disappearing forests, and an increasingly severe climate. These conditions, combined with a growing population, mean that, even absent climate change, the government and its partners face an overwhelming number of challenges in supporting these communities. Because farmers and herders integrate their adaptive responses into larger household and community strategies, support across a range of sectors — agriculture, local government capacity, transportation, or even health or education — will reduce the climate vulnerability of these communities if successfully implemented.

This assessment, however, focuses on options that more directly target climate change vulnerabilities. It has identified options that take into account the diversity of factors that characterize and create climate change vulnerability in the study zone. The options are intended to suit the dynamic nature of rural producer responses to a complex and changing context. And, due to this complexity and the importance of household decisions in addressing their perceived needs, we have not separated the proposed options by sub-zone, or associated them with specific livelihood types. They are not prescriptive remedies, but approaches intended to increase the information and options available to people on the front lines of adaptation.

The following list presents, in ranked order, the options identified through this process. A brief discussion derived from the analysis and the Multi-Criteria Analysis process accompanies each.

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[14] The initial option in English was in fact more specific. It stated "Raise awareness and capacity of **rural council members** regarding climate change and disaster management". However, in the translation to French this was changed to "communities," leaving it open wider interpretation, and a much broader activity.

Raise awareness and capacity of rural communities regarding climate change and disaster management. The extremely low capacity of local institutions could be strengthened through efforts to strengthen their ability to manage information and knowledge to assess and prioritize climate risks; improve planning to strengthen flexibility and innovation in the face of climate trends and shocks; increase capacity to be responsive to evolving community needs through greater participation; and strengthen accountability and redress power imbalances.

Strengthen national climate and early warning information system. The broad dissemination of timely, accurate, and complete climate and early warning information underpins effective climate change adaptation and disaster management. Better access to reliable weather information and forecasting would help both herders and farmers improve their decision making regarding the "what, when and where" in the management of their animals and planting their crops. It would enable both poor and wealthy households to make critical and effective low-cost adjustments to their management. While this assessment did not evaluate the capacity of national institutions to provide these services, it did identify a need for improvement. The responses of local participants in the local presentation of the assessment results, as well as the interviews with key informants conducted for the assessment, both highlighted the importance of this information. They also made clear that such information is current unavailability. (It is also worth noting the ARCC team ran into significant constraints in its efforts to acquire climate data for the assessment.) Given the ongoing importance of such information to the process of adaptation to climate change, an additional study assessing the national meteorological services would be warranted.

Strengthen systems to increase producer access to diverse and high quality seeds. Farmers regularly change the proportions and types of crops they plant as one of the most basic, widespread, and effective methods to adapt to climate. Increasing farmer access to the seed they need on a sustainable basis requires improvements to existing decentralized means to maintain seed quality and manage distribution, such as community or commercial seed banks.

Promote the integration of livestock raising in crop agriculture systems. Supporting poorer households in the South to make the shift toward the integration of livestock —particularly small ruminants and poultry — into their cropping systems will be an important factor in reducing vulnerability through the diversification of climate risk. As noted in the summary of the development context, various efforts already support this option. They include the USAID-funded Yaajeende project, and reflect a trend identified in this assessment's focus group discussions. This assessment identified two challenges to implementing this option. First, it needs to be carried out through means that do not confer an overwhelming advantage to the wealthier households, which have the available cash to invest in livestock. This assessment identified one option — supporting poultry raising by women and poorer households, perhaps through improved access to the vaccination against Newcastle virus. Second, this option needs to be implemented with the recognition that expanded livestock raising will augment existing competition over livestock resources. Focus groups in the southern study zone, in particular, cited tensions with herders external to their area. Improved governance of resource tenure may become essential.

Promote small and micro irrigation. Methods to make effective use of surface water will become increasingly important if precipitation falls in an increasingly erratic manner and the frequency of heavy events increase, as expected. This option nevertheless faces feasibility and equity challenges without which it would rank higher on the list of priorities. Further, approaches extending cultivation to currently unfarmed lowlands may result in localized environmental impact and reduce pasture lands.

Invest in research for climate-adapted crop varieties. Greater access to crop varieties that address farmer needs would clearly reduce vulnerability. For the study zone, greater access to improved short cycle, multi-purpose seeds that provide both food and forage would benefit farmers and herders.

This assessment identifies as one target improved varieties of sorghum that can be rotated with other crops. In Senegal, long-term planning, political will, and significant long-term funding are required to improve research on new crops. The institutional and human capacity constraints of the extension process also must also be overcome.

Promote market gardening and production of niche crops, such as bee keeping. This approach to diversifying agricultural livelihoods in a way that is frequently managed by and to the benefit of women currently receives significant support, with the USAID-funded Yaajeende project but one of many examples. This assessment cites a number of market-based factors that may hinder these efforts, including an absence of storage facilities at markets; market saturation at harvest; limited methods to reduce spoilage in transit; absence of processing resources and facilities; little access to inputs, tools, and parts; and weak producer cooperative networks to pool resources.

Promote field practices to strengthen the management of runoff water. Fewer farmers employ field management practices such as *demi-lunes, zai* (planting pits), and bunds in Senegal than in other countries of the Sahel. Climate change is nevertheless likely to make the management of runoff increasingly important to crop yields. Where farmers have stable and recognized rights in land, the adoption of such practices pose fewer resource tenure issues than improved management of common resources, such as pasture.

Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest. Successful implementation of this option will require mounting a sustained effort across multiple sectors and institutional levels to improve resource tenure. Participants in the national stakeholder meeting scored this option poorly due to efficiency and feasibility due to these challenges to implementation. However, if successful, it will help manage conflict and improve resilience and productivity.

Promote techniques to increase fodder production and collection. Introducing high-yield forage varieties and improving systems for the storage and sale of forage would help ease the twin burden of feed and mobility for livestock owners, both of which this assessment projects will increase in the coming years. Though it ranked low on the MCA list of priorities, the assessment team validation meeting identified this as a strong option.

Reinforce veterinary services. The households of the study zone have greater access to these privatized services than other sources of aid from outside their communities. The demand for services to improve livestock health will increase as households in the Southern zone of the study area increasingly diversify their systems into raising livestock.

Clarify tenure rights in livestock corridors and pasture. While this option would attenuate the growing tensions regarding pasture and help manage conflict and improve resilience and productivity (as with the option above to improve the management of common natural resources), it would require substantial capacity building of local governance institutions. Participants in the national stakeholder meeting scored such efforts to mitigate the growing tensions and increase overall resilience and productivity poorly due to efficiency and feasibility concerns. However, substantial experience outside of the study zone exists to draw upon.

Establish instruments for crop and livestock insurance. While it accurately targets climate-based risk, participants in the national stakeholder workshop scored this option very low on feasibility. Implementation challenges will need to be resolved before it can be widely promoted.

8.5 CONCLUSIONS FOR USAID/SENEGAL PROGRAMMING

One purpose of this assessment is to inform USAID/Senegal programming. The options presented thus far in this document do not take into consideration the portfolio and priorities of USAID/Senegal, but are appropriate for a broad audience. USAID/Senegal finalized their current Feed the Future strategy in 2012, and that strategy excludes some of the technical areas addressed in this assessment, such as livestock and road construction. It focuses on the value chains of four crops: millet, maize, rice, and sorghum. Furthermore, most of USAID/Senegal's agriculture activities lie outside the study zone, with only the large Yaajeende project operating in eastern Senegal.

Despite differences in geographic and technical focus, conclusions can be drawn from this study to inform the future work plans for Feed the Future and Climate Change Adaptation activities, and the development of the next Country Development Cooperation Strategy (CDCS). Already, many of the activities USAID/Senegal currently implements, found both within and outside of the study zone, align with recommendations of this assessment. Some of the activities worth noting include:

- Support for farmer climate-risk mitigation through rain-based index insurance for maize in the *Projet Croissance Economique* (PCE).
- Collecting critical information to reduce farmer/herder conflict though the mapping of transhumance corridors in research associated with the Yaajeende project.
- Support to seed development and distribution systems, including strengthening certification and conditioning, developing varieties, and reinforcing seed associations in the PCE.
- Promotion of a diverse range of farm-level practices to reinforce resiliency in multiple projects.
- Education and research efforts to develop and strengthen adaptive practices, including Conservation Farming, and techniques for forage crop storage in the Education and Research in Agriculture project.

These examples demonstrate that mission programming has already begun to target important avenues to address climate variation and extremes by strengthening farmer resilience, mitigating their risk, improving their access to a diverse variety of improved seeds and practices, and mitigating farmer/livestock conflict. Of the proposed research and extension options presented in this assessment, exclusive of livestock, the only topic the mission does not seem to currently address in some form is improved weather forecasting and market information.

Greater insight into the extent to which USAID/Senegal has mainstreamed a climate change perspective into its current activities would require research and dialogue focused to this end, as well as assumptions concerning regions of Senegal not studied in this assessment. This assessment has nevertheless highlighted certain principals that should be taken into consideration when mainstreaming climate change adaptation into agricultural programming in Senegal and in the development of their new CDCS. The mission should plan for:

The possibility that in coming decades annual rainfall levels will return toward those experienced in the 1970s and 1980s. That Senegal's climate future may resemble a known past can make planning and communication efforts more concrete, though real differences will exist in context and climate. For one, higher temperatures will aggravate the impact of decreased rainfall.

Continued spatial and temporal climatic uncertainty at multiple timescales. Rainfall timing and intensity will continue to vary unpredictably across the country, within seasons, between years, and across decades, reinforcing producer need for diverse options in technical solutions, effective risk-

mitigating services, and governmental and technical services responsive to emerging needs. Investments will need to effectively address a range of possible future conditions.

Increased frequency of extreme events. A greater frequency of concentrated rainfall and flooding events may paradoxically accompany decreased annual rainfall amounts, further decreasing moisture available to crops, hindering transportation, challenging water capture structures, and taxing response services.

Increased frequency of failed years for crop and livestock production. While the droughts of the 1970s and 1980s were each the result of a specific confluence of events, it would be pragmatic to plan for rural populations to respond to the decreased viability of rain-fed agriculture through increased migration, and increasing the importance of early warning systems and safety nets for the poorest.

Greater impact on crops and pasture in the North increasing pressure in the South. The dynamics will differ across Senegal, but the precarious nature of agriculture in the north is likely to increase the tendency for people and livestock to shift South when possible.

Greater pressure on moist low lands and pond ecosystems. Climate change can be expected to aggravate this trend to exploit, through cultivation or otherwise, fertile lowlands, to the detriment of natural resources and the loss of the environmental services they provide.

Impacts to be most strongly felt by groups who are currently the most vulnerable. Climate change will impact different segments of the population differently; a harsher climate will reinforce the importance of USAID's ongoing efforts to identify and address the specific needs of people who are the most disadvantaged.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES A – F

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African and Latin American Resilience to Climate Change Project

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REPUBLIQUE DU SENEGAL

ETUDE CLIMATIQUE DANS LE NORD-EST DU SENEGAL

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EXECUTIVE SUMMARY

This climate study is focused on the North-East departments of Senegal (Matam, Kanel, Bakel, and Goudiry), the ARCC project's study area.

It was conducted using rain, temperature, humidity, and wind data, and by applying analyses and simple statistical tests.

The spatial distribution shows that the highest total rainfall levels (520-400 mm) were observed in the Goudiry and Bakel departments, and the lowest in the Matam and Kanel departments (250-320 mm).

In the northern departments (Matam and Kanel), the rainy season starts at the beginning of July (July 5-15) and ends in late September. In the southern departments (Bakel and Goudiry), the rainy season begins around June 20 and ends around October 10.

The rainy season lasts 70 to 80 days in Matam and Kanel, versus 90 to 110 days in Bakel and Goudiry.

The results showed an increase in precipitation over time. Indeed, the 1970s and 1980s are marked by significantly lower rainfall compared to the 1990s and 2000s. In the study area, the increase in percentage is more significant in the north (15% in Podor, 19% in Matam) compared with the south (0% in Goudiry, and 1% in Bakel).

Rainfall extremes (P>= 40 mm) are characterized by an upward trend for Bakel, Podor, Matam, and Kanel, with a drop for Goudiry. For all stations, the extreme values accumulated in one day did not exceed 160 mm.

The other climatic parameters are marked by an increase in average values between the 1971-1990 period and the 1991-2010 period.

RESUME

L'étude du climat s'est concentrée sur le Nord-Est (département de Matam, Kanel, Bakel et Goudiry), zone d'étude du projet ARCC.

Elle a été réalisée en utilisant les données de pluie, de température, d'humidité et de vent et en appliquant des analyses et tests statistiques simples.

La distribution spatiale montre que les plus forts cumuls pluviométriques (520-400 mm) sont observés dans les départements de Goudiry et Bakel et les plus faibles dans les départements de Matam et Kanel (250-320 mm).

Concernant le démarrage de la saison des pluies, il intervient en début juillet (5-15 juillet) alors qu'au sud, c'est autour du 20 juin qu'on l'observe, tandis que la fin est observée en fin septembre dans le nord de la zone l'étude et vers le 10 octobre au sud.

Enfin, la durée de la saison des pluies est de 70 à 80 jours au nord (Matam et Kanel) contre 90 à 110 jours au sud (Bakel et Goudiry).

Les résultats ont montré une évolution des précipitations au cours du temps. En effet, les années 1970 et 1980 sont marquées par une pluviométrie significativement plus faible par rapport aux décennies 1990 et 2000. Le pourcentage de hausse est plus significatif au nord (15% à Podor, 19% à Matam et 19% à Bakel) par rapport à l'extrême sud de la zone d'étude (0% à Goudiry, 2% à Tambacounda).

Les extrêmes de pluies (P>=40 mm) sont caractérisés par une tendance à la hausse pour Bakel, Podor, Matam et Kane une baisse pour Goudiry. Pour toutes les stations, les valeurs extrêmes cumulées en 1 jour ne dépassent pas 160 mm.

Les autres paramètres climatiques sont marqués par une hausse des valeurs moyennes, en passant de la période 1971-1990 à la période 1991-2010.

INTRODUCTION

Le Sénégal a un climat de type sahélien, qui se caractérise par une forte saisonnalité des pluies, grande variabilité interannuelle de la pluviométrie ainsi qu'une évolution plus lente avec des années sèches plus fréquentes au cours de la période 1971-90, comparativement à la période 1991-2010. En effet, l'évolution des écarts pluviométriques moyens annuels montre une nette augmentation de la fréquence des années déficitaires depuis 1970.
A cette situation s'ajoute :

- un taux de croissance démographique qui atteint en moyenne 6% par an, entre 1960 et 1990, d'après l'étude prospective à long terme de l'Afrique de l'Ouest faite par le Club du Sahel de l'organisation de coopération et de développement économiques (FIDA, 2001),
- et une faible utilisation d'intrants agricoles entre 7 à 8 Kg/ha.

Cette situation doit stimuler des études pour asseoir des programmes et politiques de développement durables. Ainsi, l'analyse climatique constitue une approche pertinente pour la compréhension des contraintes agricoles liées au climat. Elle permet de disposer d'indicateurs qui aident la planification et la prise de décision.

La présente étude est réalisée dans les régions de Matam et de Tambacounda et couvre les départements de Matam, Kanel, Bakel et Goudiry (Figure 1). Elle fait le point sur l'évolution de la pluviométrie et des autres paramètres climatiques dans la région, mais également sur la caractérisation des dates de démarrage et de fin de saison pluvieuse, et le retour probable des extrêmes pluviométriques et s'insère dans le cadre d'une étude plus large, sur la vulnérabilité aux conditions climatiques conduite dans le cadre du projet ARCC.

Le présent rapport est présenté selon le plan suivant :

1. Caractéristiques générales du climat au Sénégal
2. Données et méthodes pour l'étude du climat dans la zone Nord-Est
3. Caractérisation de la pluviométrie au Nord-Est
4. Analyse des autres paramètres climatiques dans la zone Nord-Est
5. Conclusion

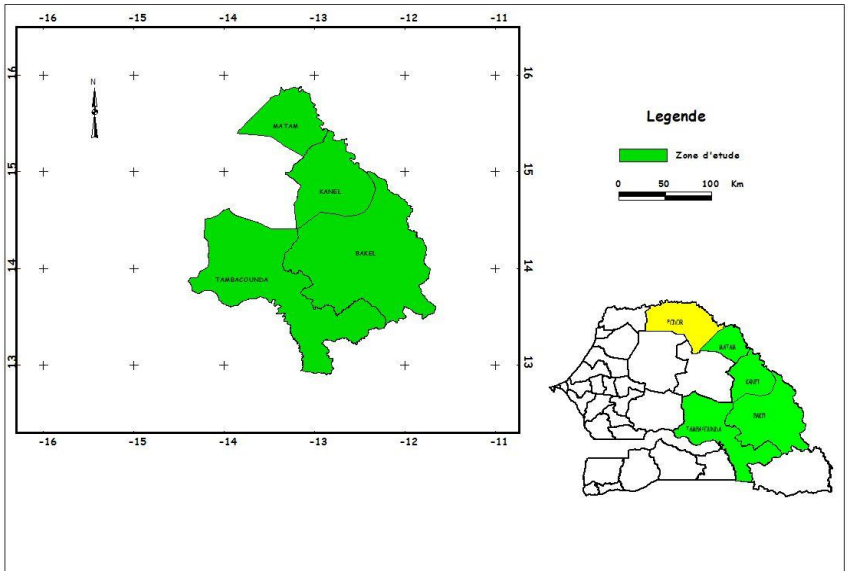

FIGURE 1. Localisation des différents sites de la zone d'étude (en jaune le département de Podor qui fait l'objet d'étude mais n'est pas inclus dans la zone d'étude).

CARACTERISTIQUES GENERALES DU CLIMAT AU SENEGAL

Bien que contenu dans son ensemble dans le climat de type sahélien à l'échelle du Sénégal le climat présente un certain nombre d'inhomogénéités, présentées sur les figure 2 et 3. On remarque notamment un fort gradient dans les cumuls pluviométriques annuels avec des cumuls dépassant 1000 mm dans le sud et n'atteignant guère 200 mm dans le nord. Ces différences dans les totaux annuels précipités s'accompagnent de différences dans la longueur de la saison des pluies, donc la longueur de la saison agricole, allant de plus de 120 jours dans le sud à moins de 50 jours dans le nord du pays, en règle générale entre les mois de juin et octobre avec une concentration en août et septembre.

La répartition spatiale des températures moyennes reflète en partie le même gradient Nord-Sud mais est surtout dominée par un contraste entre l'est du pays, plus continental et plus chaud et l'ouest sous influence des entrées maritimes avec des températures plus modérées (fig.3).

Outre ces contrastes spatiaux le climat présente également des variations saisonnières ainsi que des variations interannuelles et décennales dont il faut tenir compte. Celles-ci sont examinées plus en détail dans la zone d'étude.

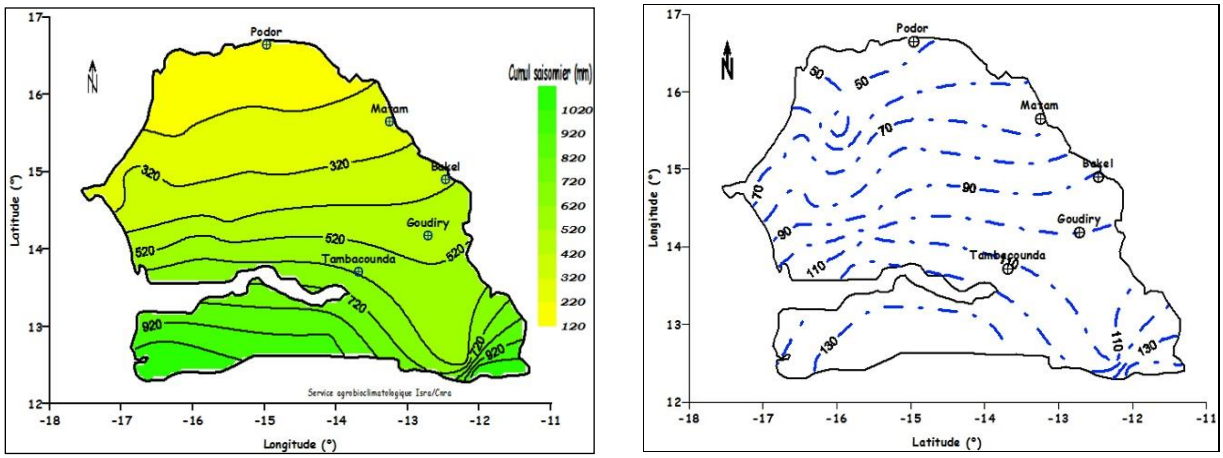

FIGURE 2. Répartition spatiale des caractéristiques de précipitations au Sénégal. Gauche : précipitations annuelles moyennes sur la période 1971-1990 (en mm/an); droite : longueur moyenne de la saison des pluies (en jours). *Source : données ANACIM*

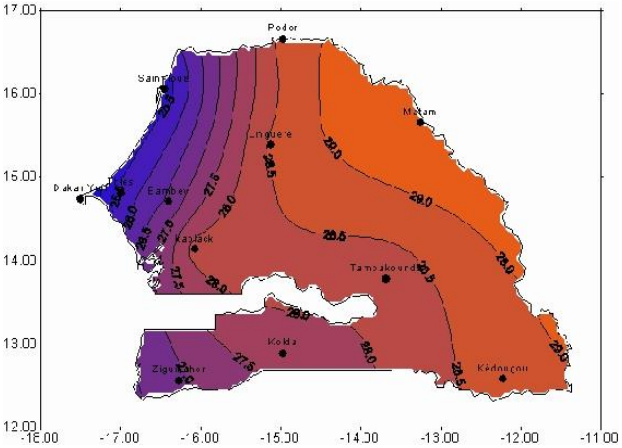

FIGURE 3. Répartition spatiale des températures moyennes au Sénégal (en °C). *Source :* *http://www.iao.florence.it/training/geomatics/Thies/Senegal_23linkedp6.htm*

DONNEES ET METHODES

Les données climatiques de 6 stations sont utilisées sur la période 1971-2010. Il s'agit des stations de la zone d'étude (Matam, Kanel, Bakel et Goudiry) et de 2 stations qui servent à renforcer le dispositif (Tambacounda et Podor). Les données journalières proviennent pour l'essentiel du service chargé de la Météorologie. Elles sont utilisées comme base de traitement pour générer les cartes présentées dans ce travail. Il faut signaler que les cartes administratives de base proviennent de l'agence nationale chargé de la cartographie.

Pour chaque station les principaux paramètres important pour les cultures (pluies, température, humidité relative et insolation) sont analysés en termes de :

- caractéristiques moyennes afin de comparer les différents sites entre eux
- variabilité interannuelle présentée sous forme de séries temporelles et/ou d'écart type et/ou coefficient de variation
- évolution a long terme sous forme de différences entre les périodes 1971-90 et 1991-2010. L'évolution des paramètres entre les deux sous périodes est caractérisée en utilisant le test de Newman Keuls qui permet de vérifier la significativité de la différence entre ces deux périodes.

CARACTERISATION DE LA PLUVIOMETRIE AU NORD-EST DU SENEGAL: ANALYSE DE LA PLUVIOMETRIE MOYENNE ET DE SA VARIABILITE INTERANNUELLE

Les principales caractéristiques de l'inhomogénéité spatiale de la pluie au niveau du Sénégal se retrouvent dans la zone d'étude. En effet, les plus importants cumuls se retrouvent au sud, notamment dans les départements de Goudiry et Tambacounda où les moyennes annuelles sur la période 1971 – 2010 sont de 616 mm et 718 mm respectivement. Au nord de la zone la pluviométrie moyenne est de 344 mm à Matam et 218 mm à Podor, pour la même période. Ces valeurs varient d'une année à l'autre et les plus faibles totaux annuels enregistrés sur cette période se trouvent également au Nord de la zone avec 57 mm à Podor et de 142 mm à Matam. A l'inverse certaines années le cumul peut dépasser le double de la moyenne (tableau 1). La figure 4 montre plus en détail l'évolution temporelle des cumuls annuels au cours de la période 1971 – 2010.

TABLEAU 1 : CARACTÉRISTIQUES MOYENNES DE LA PLUVIOMÉTRIE DANS LA ZONE D'ÉTUDE (1971-2010)

	Pluie (mm)		
Stations	moyenne	Min	Max
Podor	218	57	490
Matam	344	142	600
Bakel	507	247	811
Goudiry	616	422	854
Tambacounda	718	408	1111

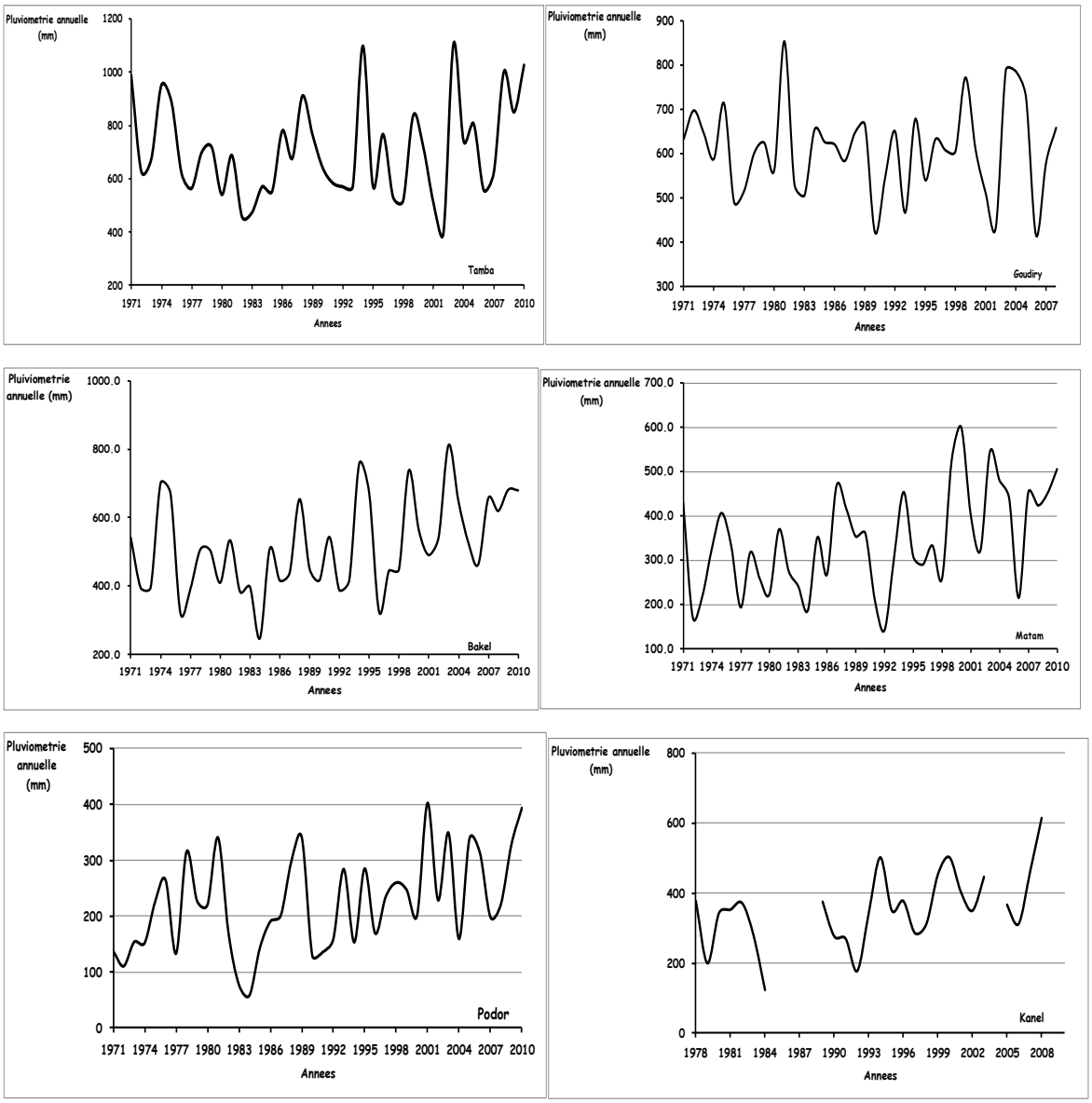

FIGURE 4. Evolution temporelle de la pluviométrie pour la période 1971-2010 pour les 6 stations de la zone nord-est.

De manière générale, la variabilité interannuelle de la pluviométrie en Afrique de l'ouest a été analysée par différents auteurs (Fontaine, 1991 ; Moron, 1994 ; Camberlin et Diop, 1999) qui ont établi une télé-connexion statistique entre la pluie ouest africaine et les températures de surface océanique au large du pacifique sud.

Analyse de l'évolution décennale de la pluviométrie

Pour évaluer les variations de la pluviométrie annuelle, nous avons utilisé les cumuls annuels enregistrés. L'évolution de la pluviométrie pour la période 1971-2010 montre une hausse entre 1991 et 2010 par rapport à la période 1971-1990 (Tableau 2). Le pourcentage de hausse est plus important à Matam et Bakel (19%), alors que la pluviométrie reste stable à Goudiry. Ces résultats mettent en évidence la tendance lente au retour des années plus humides au Sénégal et particulièrement dans le Nord-Est.

TABLEAU 2 : COMPARAISON DE TOTAUX PLUVIOMÉTRIQUES ANNUELS MOYENS POUR LES DIFFÉRENTES STATIONS ENTRE LES PÉRIODES 1971-1990 ET 1991-2010

Stations	Moy71_90 (mm/an)	Moy91-10 (mm/an)	Différence (mm/an)	Difference relative (%)
Podor	194	228	34	15%
Matam	315	391	76	19%
Bakel	464	570	106	19%
Goudiry	610	612	2	0%
Tambacounda	709	722	13	2%

**significatif, NS : non significatif*

Ces résultats confirment l'évolution synchrone de la pluviométrie sur la zone considérée et dans l'ensemble du Sénégal (Diop, 1999). La variabilité pluviométrique a été aussi analysée sous l'angle des caractéristiques intra-saisonnières : l'intensité des pluies et la fréquence des séquences sèches longues.

Analyse des fortes précipitations

Les très fortes pluies sont sources d'inondation et de destruction des habitations souvent peu solides en milieu rural dans cette zone. Le seuil de 40 mm/jour a été sélectionné pour la définition des précipitations fortes, car il a souvent été utilisé en Afrique soudano-sahélienne pour caractériser une forte pluie (Le Barbé *et al.* 2002 ; Sultant et Jacinot, 2003).

L'analyse du tableau 3 montre que le nombre de pluies extrêmes (supérieures à 40 mm) est plus important dans la partie sud de la zone d'étude (87 à Goudiry, 101 à Bakel et 103 à Tambacounda). Les maxima journaliers enregistrés y sont egalement légèrement plus forts, autour de 145 mm alors qu'ils ne sont que de 120-130 mm à Bakel à Matam et seulement 75 mm à Podor (tableau 3).

TABLEAU 3. STATISTIQUES DESCRIPTIVES DES EXTRÊMES PLUVIOMÉTRIQUES >=40 MM POUR LA ZONE EST DU SÉNÉGAL DE 1971-2010 (LA SÉRIE DE PLUIE JOURNALIÈRE S'ARRÊTE EN 2000 À GOURDIRY).

Localités	Nb de valeurs	Moyenne	Ecart Type	Minimum	Médiane	Maximum
Goudiry	87	56.54	20.05	40	49.5	145
Matam	62	57.4	19.9	40	49.4	131.6
Bakel	101	56.4	16	40	52.5	120
Podor	36	54.2	11.2	40	50.5	75.9
Tamba	103	56.6	17.3	40	51.3	144.6

Analyse des séquences sèches longues

Les pauses sèches prolongées au cours de la saison des pluies peuvent provoquer un stress hydrique chez les plantes cultivées. Leur répartition pendant les mois de juillet, août et septembre a donc été analysée pour évaluer ce risque hydrique.

Les résultats du tableau 4 montrent que, quel que soit le mois considéré, le risque d'avoir des pauses pluviométriques supérieures à 10 jours est plus élevé dans la partie nord que dans la partie sud (tableau 2). En juillet, la probabilité est supérieure à 50% au nord et inférieure à 45% au sud. En août et septembre, la probabilité d'avoir de longues séquences sèches diminue par rapport à juillet, mais reste élevée dans la partie nord, alors qu'elle est faible à Bakel (21%) et nulle à Goudiry.

TABLEAU 4. PROBABILITÉ D'AVOIR DES SÉQUENCES SÈCHES SUPÉRIEURES OU ÉGALES À 10 JOURS (1971-2010). (*LA SÉRIE DES DONNÉES JOURNALIÈRES S'ARRÊTE EN 2000)

Stations	En juillet	En Août	En Septembre
Podor	86	53	68
Matam	57	32	42
Bakel	45	10	21
Goudiry*	43	22	0
Tambacounda	18	8	6

Détermination des dates de début, de fin et de la longueur de la saison agricole

La caractérisation de la saison de culture permet de s'assurer au mieux de la réussite des semis. Pour ce faire, les critères pertinents validés au Sahel ont été utilisés pour déterminer le début de l'hivernage dans la région Nord-Est et Est du Sénégal. La date de démarrage de la saison des pluies est définie comme le premier jour, après le 1er mai (jour julien n°122), où un cumul pluviométrique de 20 mm cumulé en un ou deux jours ne soit pas suivi de séquences sèches de plus de 10 jours dans les 30 jours qui suivent (Sivakumar, 1988 ; Stern et *al.*, 1982 ; Gueye et Sivakumar, 1992, Diop, 1996).

La détermination de la date de fin repose sur le critère du bilan hydrique, qui considère la date de fin de la saison des pluies celle à laquelle la consommation en eau de la plante épuise la réserve hydrique du sol et ceci à partir du premier septembre (Stern et *al.*, 2006). Pour cela, nous avons considéré la réserve utile (RU) des sols des différentes stations sélectionnées et utilisées par Forest (1982). La longueur de la saison agricole est la différence entre les dates de fin et de début de la saison des pluies. Ces deux dates sont exprimées en jours juliens (Sivakumar et Guèye, 1992).

La répartition spatiale des dates moyennes de début et fin de la saison des pluies est présentée sur la figure 5. Une variation latitudinale des dates de début et de fin est observée. Dans la partie Nord de la zone d'étude, la saison des pluies démarre en début juillet (5-15 juillet) alors qu'au sud, c'est autour du 20 juin qu'elle démarre. La fin de saison pluvieuse intervient en fin septembre dans le nord de la zone l'étude et vers le 10 octobre au sud (figure 5).

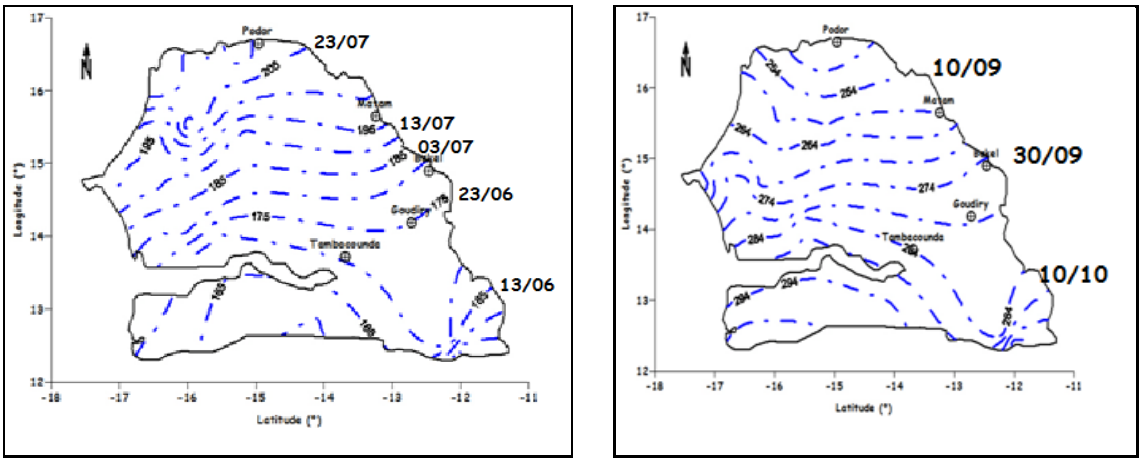

FIGURE 5. Répartition spatiale des dates moyennes de début (à gauche) et de fin (à droite) de la saison agricole au Sénégal (isolignes exprimés en jour Julien) Données de 1950-2010. *Sarr, 2013*.

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L'analyse de la variabilité des dates de début et fin de la saison ainsi que de sa longueur montre une grande variabilité d'une année à l'autre, surtout de la date de démarrage et de la longueur de la saison, la fin de la saison étant un peu plus stable. Le démarrage et la durée de la saison peuvent varier de plus de 20 jours (à l'exception de Tambacounda) ce qui dans le cas de Bakel, Matam et Podor représente plus de 30 % de la durée de la saison (plus de 50% à Podor). Seule la station de Tambacounda, également la plus humide, montre une stabilité du démarrage et une variabilité relative de la saison plus faible. Il faut noter que l'amplitude de cette variabilité ne change pas entre les deux périodes 1971-90 et 1991-2010.

Cette caractérisation de la durée de la saison pluvieuse est fondamentale dans le choix des cycles des variétés à cultiver.

TABLEAU 5. MOYENNE, ÉCART TYPE ET COEFFICIENT DE VARIATION DES DATES DE DÉBUT ET DE FIN DE SAISON POUR LES PÉRIODES 1971-1990 ET 1991-2010.

Bakel (1971-2010)						
	Période 1971-1990			Période 1991-2010		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	30 juin	23 sept	74	24 juin	03 oct	76
Ecart Type	18	15	22	18	13	23
Matam (1971-2010)						
	Période 1971-1990			Période 1991-2010		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	16 juil	12 sept	58	16 juil	17 sept oct	63
Ecart Type	21	13	25.5	18	13	26
Podor (1971-2010)						
	Période 1971-1990			Période 1991-2010		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	25 juil	05 sept	42	27 juil	10 sept	45
Ecart Type	20	10	22	18	13	20
Goudiry (1971-2000)						
	Période 1971-1990			Période 1991-2000		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	30 juin	23 sept	85	24 juin	03 oct	100
Ecart Type	29	16	25	25	11	29
Kanel (1971-2008)						
	Période 1971-1990			Période 1991-2008		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	02juil	14 sept	73	07 juil	17 sept	72
Ecart Type	12	11	11	23	09	25
Tambacounda (1971-2010)						
	Période 1971-1990			Période 1991-2010		
	Début	Fin	Durée	Début	Fin	Durée
Moyenne	27 juin	26 sept	91	03 juil	05 oct	106
Ecart Type	06	15	17	06	18	20

En conclusion, il y a une forte relation entre les cumuls pluviométriques et la durée de la saison des pluies : les plus forts cumuls pluviométriques sont observés dans les régions où la durée de la saison des pluies est plus longue. Dans la zone d'étude, c'est au sud (départements de Goudiry et Bakel) qu'on observe les plus forts cumuls pluviométriques (entre 520 mm et 400 mm) et les plus longues durées de saison pluvieuse (entre 90 et 110 jours) (**Figure 6**). Au nord (Matam et Kanel), les cumuls sont compris entre 320 mm et 250 mm avec une saison qui dure 70 à 80 jours.

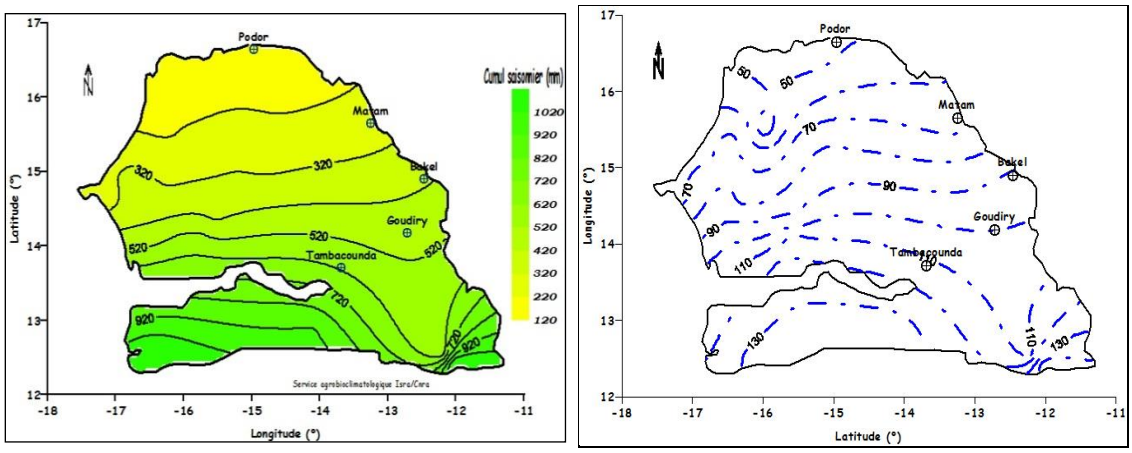

FIGURE 6. Variation du cumul saisonnier et de la longueur moyenne de la saison agricole au Sénégal (données de 1950-2010 et de 1977-2010). *Sarr, 2013*.

ANALYSE DES AUTRES PARAMÈTRES CLIMATIQUES

Température

Les températures minimales et maximales présentent en moyenne annuelle des variations spatiales faibles, de l'ordre de 1°C (entre 21.7 et 22.8) pour les températures minimales et 2°C (35.6 a 37.5) pour les températures maximales, selon un gradient sud-nord (tableau 5). Les variations interannuelles de ces moyennes annuelles sont également faibles, de l'ordre de 0.5-0.8C c'est à dire moins de 3%.

C'est à l'intérieur de l'année que les températures varient le plus, en fonction de la saison. En effet, la plupart des stations du Sahel présentent deux maxima (en Mai - Juin et en Octobre) et deux minima (en Décembre - Janvier et en Août - Septembre) (**Figure 7**), avec des écarts pouvant dépasser 10°C. Le minimum d'Aout-Septembre, plus marqué dans les températures maximales, est liée à la saison des pluies, le couvert nuageux et l'évaporation qui l'accompagnent. Le minimum de Décembre –Janvier, plus marqué que le précédant correspond à la saison fraîche (hiver) marquée par l'intrusion de masses d'air froides en provenance du Sahara.

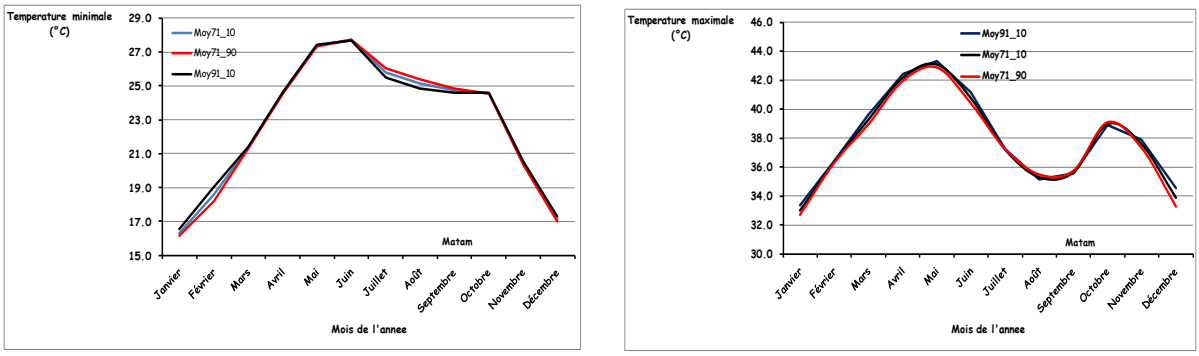

FIGURE 7. Distribution saisonnière de la température dans le nord-Est du Sénégal entre 1971 à 2010.

Les moyennes annuelles de températures minimales et maximales ont connu dans toutes les stations une augmentation entre les sous-périodes 1971-1990 et 1991-2010 (**Tableau 6**). Par contre les coefficients de variations sont restés stables, autour de 1-3%.

Les variations spatiales et temporelles des températures sont très faibles comparées aux précipitations. Ainsi la faible variabilité spatiale des températures permet d'assumer, dans le cadre de la modélisation des cultures, une bonne représentativité des conditions de température dans une station donnée pour une aire relativement importante.

TABLEAU 6. VARIATION DE LA TEMPÉRATURE MINIMALE (TN) ET MAXIMALE (TX) POUR LES STATIONS DE MATAM ET DE PODOR POUR LES SOUS-PÉRIODES DE 1971-1990 ET 1990-2010 (POUR PODOR LA 2E SOUS-SÉRIE S'ARRÊTE EN 2009)

Period	Number of values	Mean	Standard Deviation	Range	Minimum	Median	Maximum	Coefficient of Variation
				Tn				
				Matam				
Serie71_90	20	22.8	0.8	2.7	21.4	22.9	24.1	3%
Serie91_10	20	22.8	0.5	2.0	22.0	22.8	24.0	2%
				Podor				
Serie71_90	20	21.7	0.6	2.3	20.6	21.6	22.9	3%
Serie91_09	19	22.0	0.4	1.3	21.5	22.0	22.8	2%
				Tamba				
Serie71_90	20	22.1	0.6	2.1	21.1	22.1	23.2	3%
Serie91_09	19	22.3	0.5	2.0	21.3	22.3	23.3	2%
				Tx				
				Matam				
Serie71_90	20	37.6	0.7	2.1	36.5	37.6	38.6	2%
Serie91_10	20	38.0	0.5	2.2	36.8	38.0	38.9	1%
				Podor				
Serie71_90	20	36.5	0.7	2.3	35.3	36.5	37.7	2%
Serie91_09	19	37.0	0.5	1.8	36.0	37.1	37.8	1%
				Tamba				
Serie71_90	20	35.6	0.5	2.1	34.4	35.6	36.5	1%
Serie91_09	19	36.4	0.4	1.7	35.4	36.5	37.1	1%

Analyse de la variabilité

Une analyse plus approfondie de la variabilité de températures minimales et maximales dans le trois stations disponibles a été faite pour la saison des pluies et la saison sèche séparément afin de mieux identifier les nuances dans leurs évolutions..

Pendant la saison sèche, Novembre a Mai, les températures maximales et minimales ont connu en général une augmentation marquée entre 1971-90 et 1991-2010 (figures 6 et 7). Cette augmentation n'a pas été aussi nette à Podor ou la moyenne 1991-2010 est influencée par 1999, particulièrement froide à Podor. Pendant la saison des pluies une augmentation a également été observée dans les températures maximales alors que les températures minimales ont diminué a Matam et Tambacounda et augmente moins à Podor, probablement en relation ave une augmentation des précipitations constatée entre ces deux périodes.

Température minimale

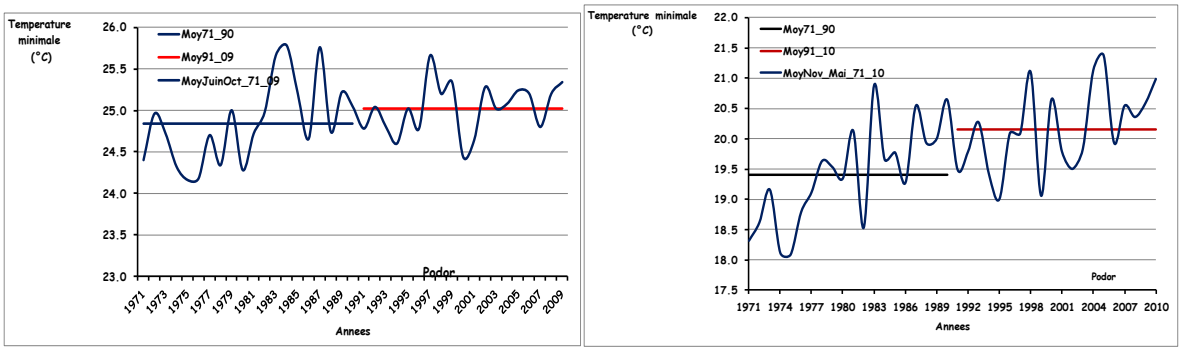

FIGURE 8a. Evolution de la température minimale pour Podor en saison des pluies (juin-octobre, gauche) et en saison sèche (novembre-décembre, droite) pour la période de 1971 à 2010.

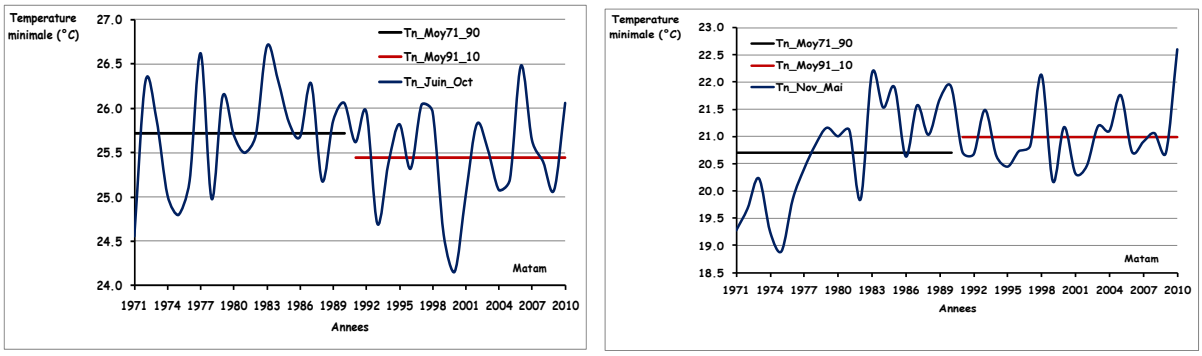

FIGURE 8b. Evolution de la température minimale pour Matam en saison des pluies (juin-octobre, gauche) et en saison sèche (novembre-décembre, droite) pour la période de 1971 à 2010.

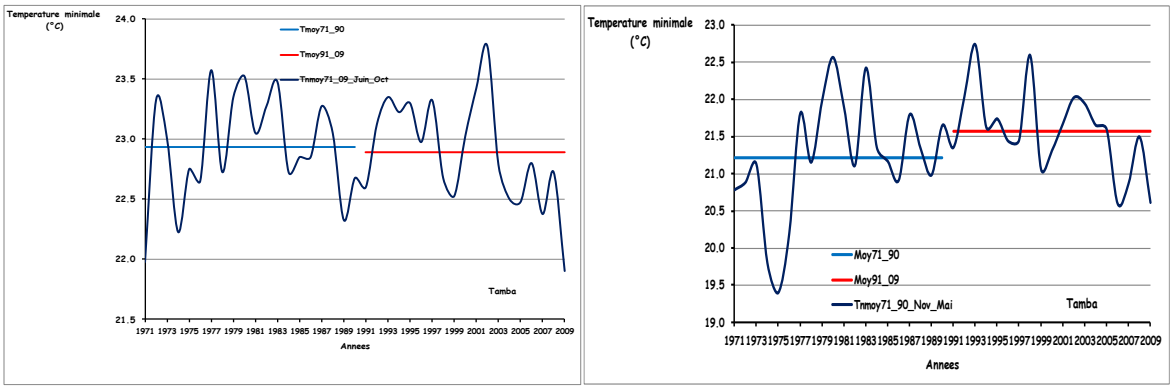

FIGURE 8c. Evolution de la température minimale pour Tamba en saison des pluies (juin-octobre, gauche) et en saison sèche (novembre-décembre, droite) pour la période de 1971 à 2010.

Température maximale

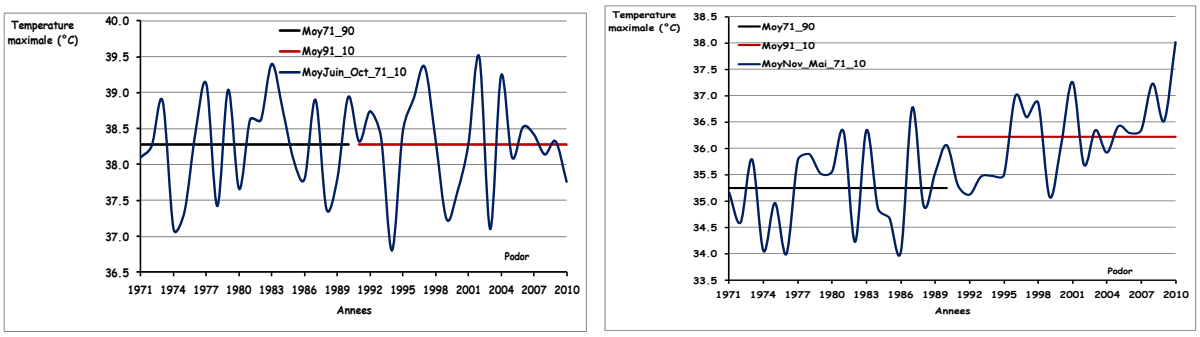

FIGURE 9a. Evolution de la température maximale pour Podor en saison des pluies (juin-octobre) et en saison sèche (novembre-décembre) pour la période de 1971 à 2010.

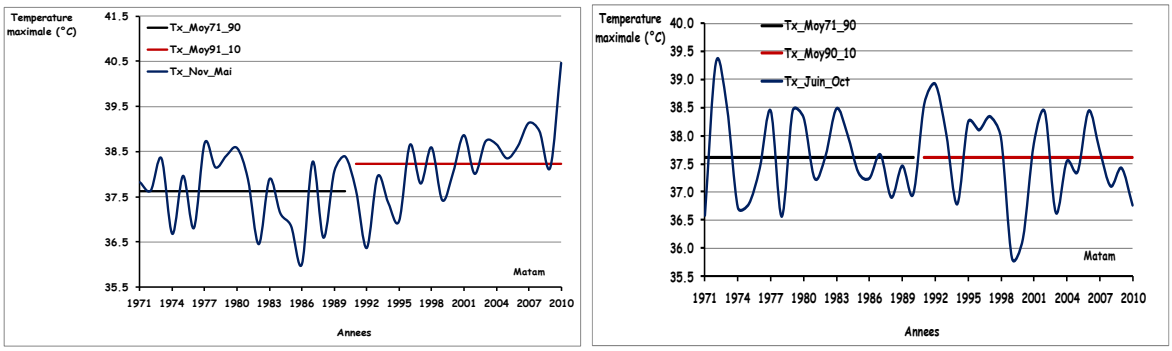

FIGURE 9b. Evolution de la température maximale pour Matam en saison des pluies (juin-octobre) et en saison sèche (novembre-décembre) pour la période de 1971 à 2010.

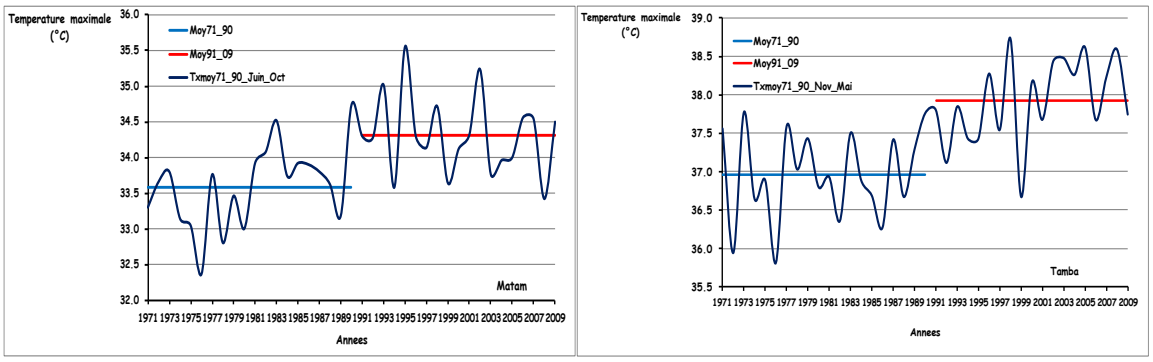

FIGURE 9c. Evolution de la température maximale pour Tamba en saison des pluies (juin-octobre) et en saison sèche (novembre-décembre) pour la période de 1971 à 2009.

Humidité relative

Les variations de l'humidité relative dépendent en partie de la température de l'air, du rayonnement et caractéristiques hygrométriques des masses d'air. Elles subissent de fortes variations saisonnières en relation avec la présence ou l'absence des masses humides liées à la mousson ouest-africaine. En effet, les valeurs les plus élevées coïncident avec le cœur de la saison des pluies (août-septembre) et les faibles en saison sèche (octobre à mai). Ainsi on peut noter que les valeurs de juin-octobre sur les courbes

dans l'annexe 3 sont doubles voire triples de celles de novembre-mai. On note une forte augmentation de l'humidité relative minimale et maximale entre les périodes 1971-190 et 1991-2010, cohérente avec une augmentation des précipitations entre ces deux périodes.

Le rayonnement solaire et l'insolation

Le rayonnement solaire et la durée de l'insolation sont des paramètres nécessaires, parmi d'autres, pour la quantification des phénomènes de l'évapotranspiration. Les fortes valeurs de radiation et d'insolation correspondent avec des températures très élevées et demande d'évapotranspiration renforcée et inversement. Dans la zone d'étude l'insolation moyenne avoisine 7 à 9.5 heures par jour en fonction de la saison : elle est légèrement plus courte pendant la saison des pluies où le ciel est souvent nuageux (Annexe 3) mais les variations saisonnières restent faibles. Si l'on note des variations interannuelles c'est surtout l'évolution de l'insolation entre les deux périodes qui domine le signal avec une diminution nette pendant la période plus récente, cohérente avec une augmentation des précipitations et des flux de mousson. Il est important de noter que, contre toute attente, ceci ne s'est pas automatiquement traduit par une baisse de températures comme montré dans la section précédente. La même tendance, observée au cours de la saison sèche ne peut cependant pas être expliquée simplement par un renforcement des flux de mousson.

CONCLUSION

Cette étude a permis de caractériser le climat du nord-est du Sénégal à travers l'analyse de paramètres climatiques observés dans 4 stations sur la période 1971-2010.

Cette caractérisation met en exergue un fort gradient nord-sud dans les précipitations et leur saisonnalité ainsi que leur forte variabilité interannuelle. Les plus forts cumuls pluviométriques et les plus longues durées de saison pluvieuse (520 -400 mm en 90-110 jours) sont observés dans les départements de Goudiry et Bakel. Au nord (Matam et Kanel), les cumuls sont compris entre 320 mm et 250 mm avec une saison qui dure 70 à 80 jours. Le démarrage de la saison des pluies, intervient autour du 20 juin dans le sud alors qu'au nord la pluie n'arrive qu'en début juillet (5-15 juillet). La saison pluvieuse prend sa fin vers le 10 octobre au sud de, elle intervient en fin septembre dans le nord de la zone l'étude et.
En outre, un changement dans la le régime pluviométrique dans la partie nord-est du Sénégal a été observe entre les années 1970 et 1980, marquées par une sécheresse qui a touché toute la zone d'étude à l'instar de la région sahélienne et la période plus récente, à partir des années 1990, ou nous assistons à un retour à des conditions pluviométriques meilleures. Ce changement ne semble pas lié à une augmentation de la durée de la saison des pluies. De travaux antérieurs avaient montré que le cumul saisonnier au Sahel est lié au nombre de jours de pluie a l'intérieur de la saison plutôt que la longueur de cette dernière ou au total journalier précipité qui reste remarquablement constant. Cependant une rapide analyse des évènements extrêmes indique une possible augmentation de la fréquence de ceux-ci qui pourrait expliquer l'augmentation des totaux saisonniers. Ces résultats corroborent ceux d'auteurs qui ont remarqué une augmentation de la fréquence des évènements extrêmes sur certaines parties du Sahel. Cependant ces résultats n'ont pas été testes et devraient être confirmés sur un nombre plus important de stations au Sénégal.
La distribution des séquences sèches présente une occurrence plus forte de ces dernières pour les mois de juillet et de septembre alors que leurs fréquence est plus faible au mois d'août, attestant d'une répartition temporelle des pluies plus régulière.
La température présente une répartition spatiale …. Et une saisonnalité avec deux minima – celui de la saison des pluies avec son couvert nuageux et celui de la saison de l'Harmattan ou les vents du nord-est apportent des masses d'air plus fraiches. La variabilité interannuelle des températures est limitée mais une tendance a la haussée entre les années 70-80 et la période récente a été notée dans la majorité des stations, surtout pour les températures maximales en saison des pluies. Celle-ci est en contradiction

avec une augmentation de l'humidité relative et une diminution de l'insolation, toutes deux en accord avec une augmentation des précipitations et du couvert nuageux. L'évolution à long terme des températures ne peut donc être expliquée par le changement dans le régime des précipitations.

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ANNEXE A1. EVOLUTION DES INDICES PLUVIOMÉTRIQUES STANDARDISÉS (IPS) POUR LES DIFFÉRENTES STATIONS

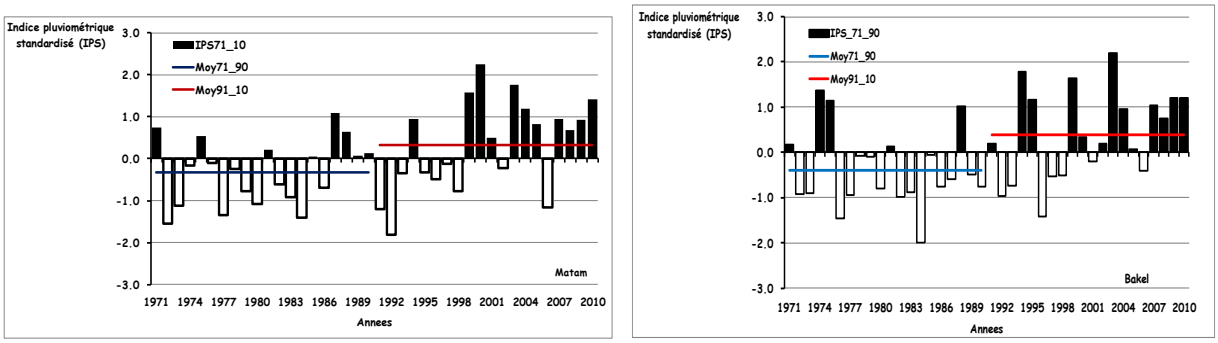


FIGURE 10a. Evolution de l'indice pluviométrique standardisé (IPS) pour la période 1971-2010 pour Matam et 1971-2010 pour le poste de Bakel

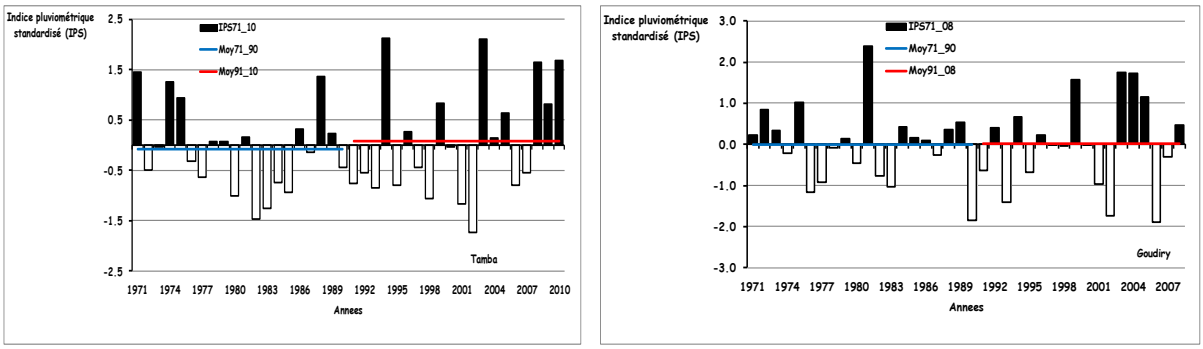


FIGURE 10b. Evolution de l'indice pluviométrique standardisé (IPS) pour la période 1971-2010 pour Tamba et 1971-2008 pour le poste de Goudiry.

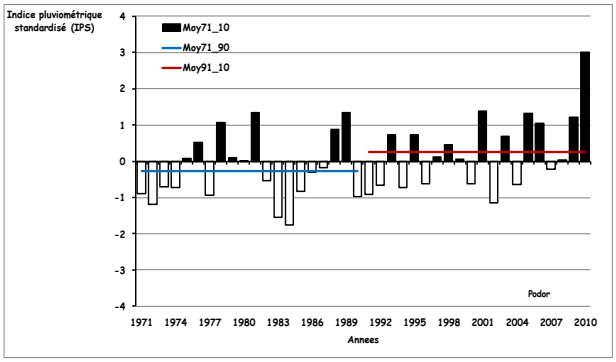


FIGURE 10c. Evolution de l'indice pluviométrique standardisé (IPS) pour la période 1971-2010 pour la station de Podor.

ANNEXE A2. APPROCHE STATISTIQUES DES EXTRÊMES DE PLUIE PAR LA LOI DE GUMBELL

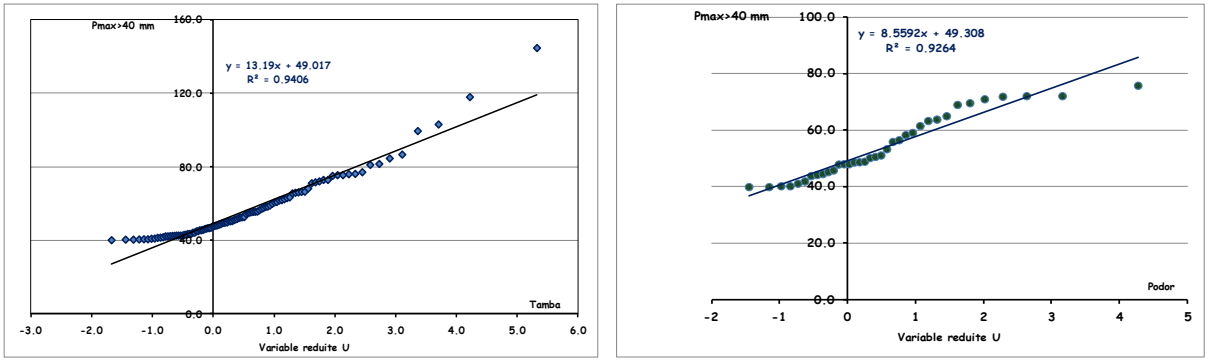


FIGURE 11a. Ajustement par une relation linéaire des extrêmes de pluie (P>=40 mm) des postes de Tamba et de Podor pour la période 1971-2010.

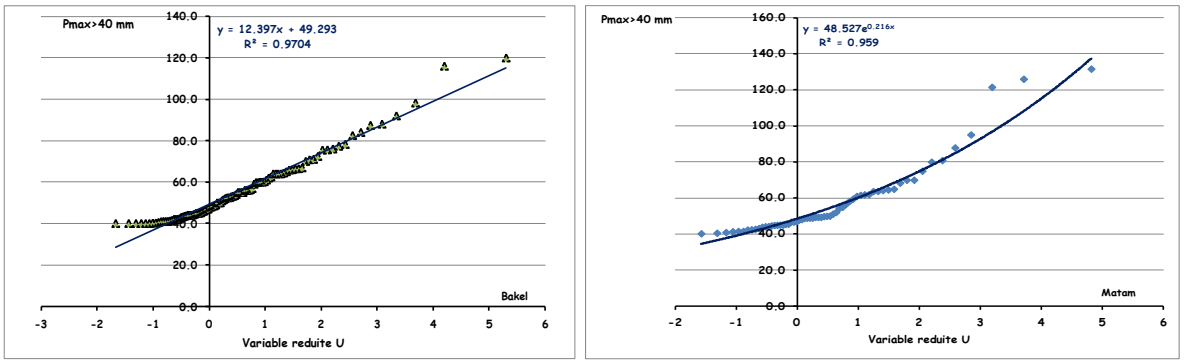


FIGURE 11b. Ajustement par une relation linéaire des extrêmes de pluie (P>=40 mm) des postes de Bakel et de type exponentielle pour Matam pour la période 1971-2010.

ANNEXE A3. HUMIDITÉ RELATIVE ET INSOLATION

Humidité relative minimale

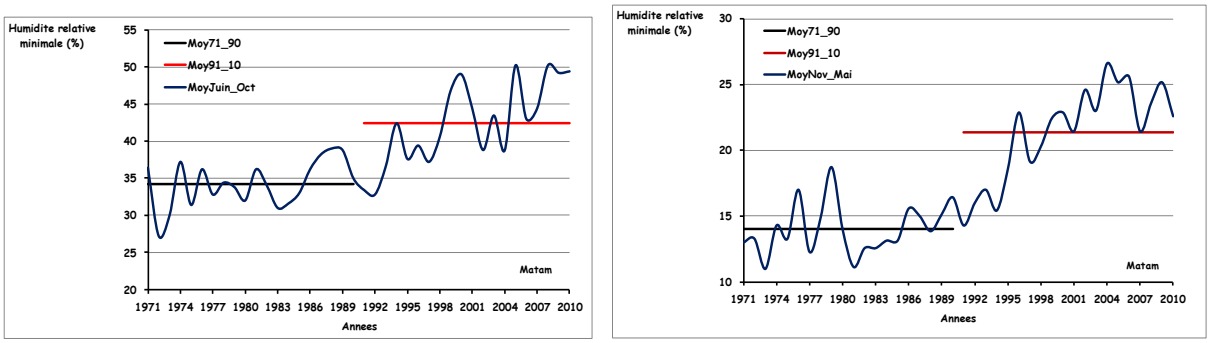


FIGURE 12a. Evolution de l'humidité relative minimale pour Matam en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.

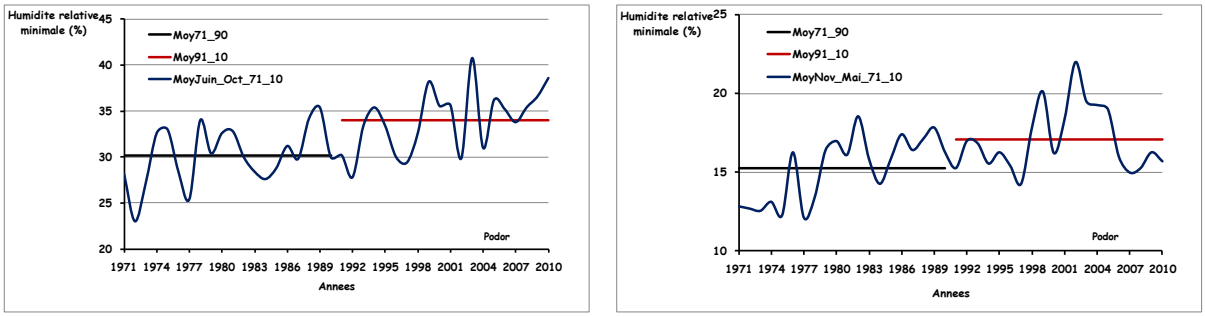


FIGURE 12b. Evolution de l'humidité relative minimale pour Podor en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.

Humidité relative maximale

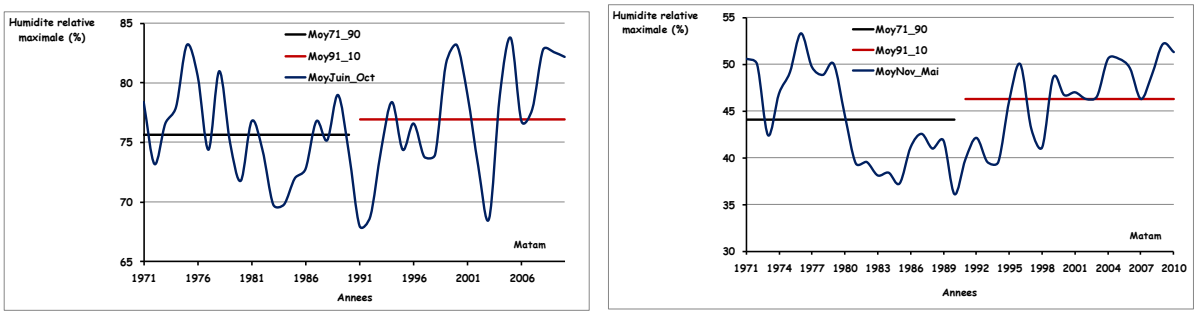
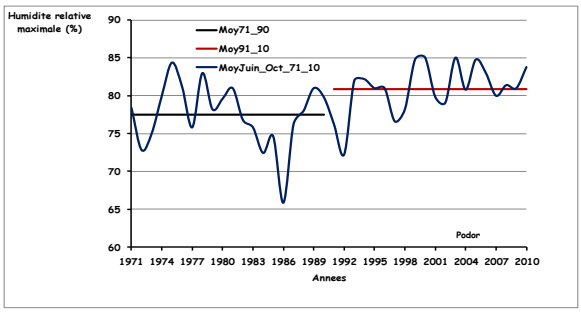


FIGURE 13a. Evolution de l'humidité relative maximale pour Matam en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.



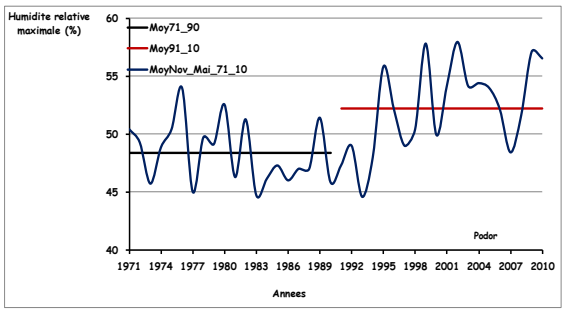
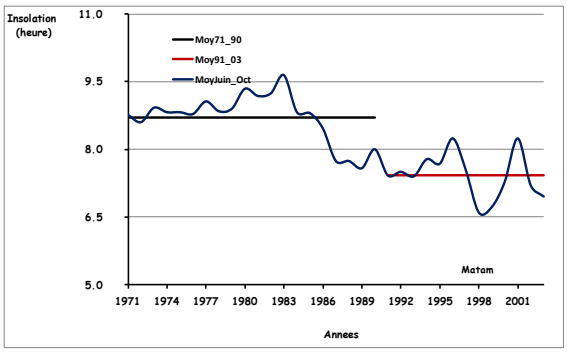


FIGURE 13b. Evolution de l'humidité relative maximale pour Podor en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.

L'insolation



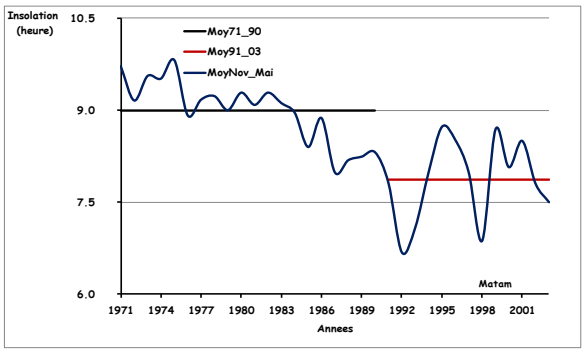
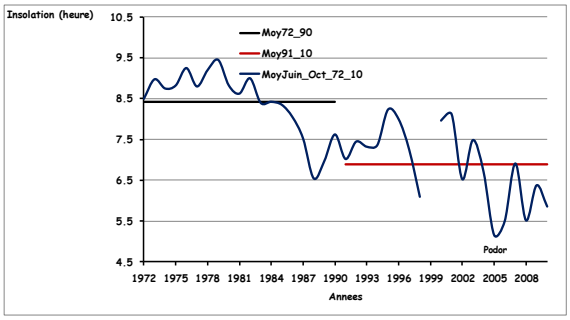


FIGURE 14a. Evolution de la durée d'insolation pour Matam en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2003.



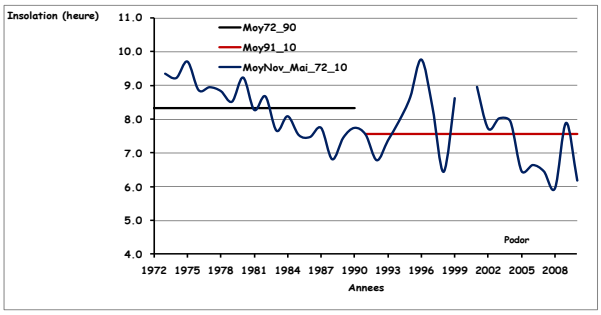


FIGURE 14b. Evolution de la durée d'insolation pour Podor en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.

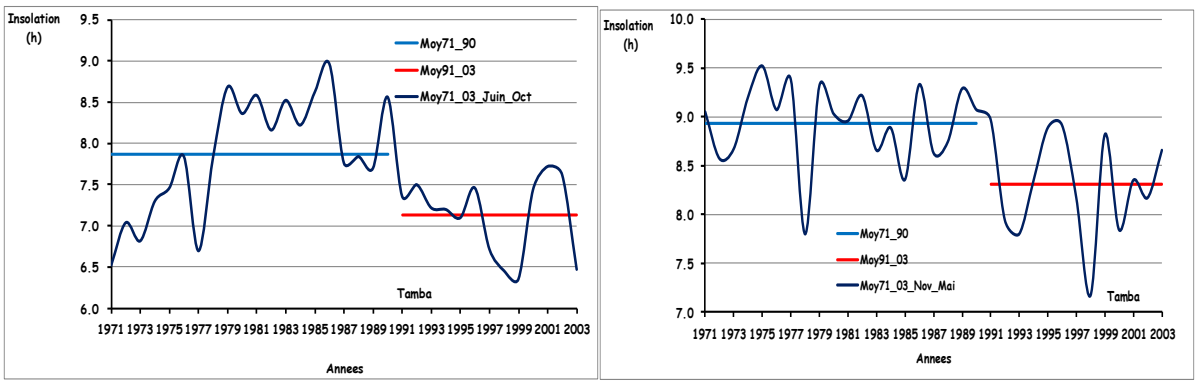


FIGURE 14c. Evolution de la durée d'insolation pour Tamba en saison des pluies (juin-octobre) et en saison sèche (Novembre-Décembre) pour la période de 1971 à 2010.

ANNEX B. RESEARCH METHODS AND IMPLEMENTATION

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INTRODUCTION

The principal methods used to implement the approach described in the main body of this report consist of fieldwork, collection and analysis of climate data and projections, crop and livestock resource modeling, literature reviews, and consultation with local experts. The data for the livelihood assessment were principally produced from key informant interviews, a survey, and focus group fieldwork. Three modeling activities based on downscaled climate projections provided the core information for the hazard-impact assessment. Mapping and spatial analysis were used to represent findings and contribute analysis to both components. Literature reviews and spatial analysis provided background on market accessibility. Focus groups and literature reviews on historical response to climate shocks, the institutional context, and opportunities in extension and research informed the understanding of adaptation options and their viability. Table 1 on the following page presents a summary of research components and methods.

TABLE 1: DESCRIPTION OF ASSESSMENT COMPONENTS

Component	#	Research theme	Research partner	Methods	Output
Livelihood vulnerability assessment (Who is vulnerable?)	1	Current household vulnerability	Institut Sénégalais de Recherches Agricoles (ISRA)	Household survey	Climate and non-climate factors that determine current vulnerability of men and women Comparison of the relative vulnerability of men and women in households engaged in pastoral, mixed, and crop-dominated systems
	2	Markets and vulnerability	ISRA	Literature review	ISRA: Vulnerability of different production systems to market fluctuations and access.
	3	Household vulnerability	CSE	Spatial analysis	Analysis of survey data mapped with other variables
	4	Institutional analysis	ISRA and WRI	KII, literature review	Rapid analysis of CRs, technical services, traders, projects following WRI Climate Change Institutional Framework
	5	Study zone climate	ISRA and CIESIN	Analysis of recent climate data	Description of climate in the study zone. Four stations: 1971–1990 vs. 1990–2010 (ISRA data). Will be compared with village perceptions.
Hazard-impact assessment (Who will become more vulnerable?)	6	Future climate	CIESIN	Downscaled Projections	Multi-model outputs for 2020–2040 and 2040–2060
	7	Impacts on crop productivity: crop thresholds	Consultant (del Rio)	Literature review	Descriptions of climate thresholds (norms of reaction) of selected crops grown in eastern Senegal by phenological stage includes maize, sorghum, millet, fonio, groundnuts, cowpea, sweet potato, and forage/grass species.
	8	Impacts on crop productivity: crop modeling	ISRA	CropWat	Projections of range of impact on productivity of selected crops for 2020–2040 and 2040–2060 (absent adaptation) Ground truth against projections for 1971–1990 vs. 1990–2010

Component	#	Research theme	Research partner	Methods	Output
	9	Impacts on diseases and pests: crops	Consultant (del Rio)	Literature review	Literature-based description of potential impact of climate change impacts on crop diseases and pests in Senegal
	10	Climate impacts on pests and diseases: livestock	ISRA	Literature review	Literature review and local expert estimates of climate change impacts on livestock in eastern Senegal by 2030 and 2050
	11	Impacts on livestock: drought/management model [NOTE: Study Discontinued]	ISRA and Consultant (ISRA/Brottem)	Modeling (mm-age)	Projected impacts of increased frequency of drought in herd size for 2030 and 2050
	12	Impacts on livestock: livestock resources	CSE	Sahelian Transpiration Evaporation and Production (STEP)	Modeling of water points, pasture, and crop residue for 2020–2040 and 2040–2060 Ground truth against projections for 1971–1990 vs. 1990–2010
	13	Impacts on transportation	CSE	Literature review	Review of existing reports and modeling of potential climate impacts on transportation routes.
Adaptation Options (What reduces vulnerability?)	14	Autonomous adaptation strategies: Focus group discussions (FGD)	ISRA	Village focus groups	Pastoral and agriculture strategies to manage climate variability and extremes in the past 20 years
	15	Autonomous adaptation strategies: Literature review	Consultant Henri Lo	Literature review	Scholarly perspectives on responses to persistent drought across the past 50 years
	16	Institutions (see number 4 above)	ISRA	Key informant interviews	Local preparedness and capacity of government, private sector, and NGOs to promote resilience (awareness of climate change, anticipation of needs, response to evolving context, and provision of robust solutions)

Component	#	Research theme	Research partner	Methods	Output
	17	Opportunities in research and extension: Literature review (ISRA)	ISRA	Literature review	Preliminary identification of promising "no regrets" and "targeted" options in research and extension
Integration of Vulnerability Assessment and Options Analysis	18	Initial Vulnerability Results Report	ARCC	Report Analysis	Initial report consolidating the three study components
	19	Cross Analysis Workshop	Representatives from research teams	Small Workshop	Refined, validated, integrated assessment conclusions Background analysis for options analysis event
	20	Options Analysis Workshop	TBD	Workshop/Report	Input from decision makers on options analysis Increased understanding of assessment results
	21	Final Vulnerability & Adaptation Options Report	ARCC	Consolidated Report	Final report

HOUSEHOLD SURVEY AND FOCUS GROUP DISCUSSIONS

Survey and Focus Group Instrument Design

The Questionnaire

The survey instrument was designed to quantify assets that households held, including income and assets to which households have access but do not control, such as public infrastructure and natural resources. It was organized following the five-asset categories of the sustainable livelihood framework: financial, natural, human, social, and physical. Food security vulnerability surveys and previous ARCC climate change vulnerability assessments informed the individual questions. Questions targeting livestock husbandry were developed following a review of similar studies. The core assessment team also evaluated the questionnaire to confirm that it would provide responses describing household climate change exposure, sensitivity, and adaptive capacity. ISRA staff reviewed the questionnaire, and during training the questionnaire was modified following clarifications and modifications proposed by enumerators who had worked previously in the study zone. (Annex C presents the final questions.)

TABLE 2: SAMPLE FRAME POPULATION IN THE TWO SUB-ZONES OF THE STUDY; POPULATIONS ARE ESTIMATES FOR 2009 BASED ON THE 2002 CENSUS

Sub-Zone	Population	%	Villages in Sample
North (Matam, Kanel)	65,477	47.4	7
South (Goudiry, Bakel)	72,431	52.6	8
Total	137,908	100	15

The Focus Group Discussion Guide

The two objectives of the focus group discussions were to provide a context for the survey results and to gain an understanding of how people have responded to changes in the climate during the past 20 years at the household level and in their cropping and livestock systems.

Discussion guides thus began with a general discussion of the village, focusing on productive activities, followed by descriptions of changes in the village during the past 20 years. The guide then proceeds to specific changes in farming and raising livestock. Reasons for each change were solicited, as were reasons for changes in the amount of investment in the two livelihood strategies. As a final topic, the guide included a discussion of the constraints to practicing agriculture and raising livestock. (Annex D contains an example of the final focus group guide.)

Sampling Strategy: Village and Household

The study focuses on rural livelihoods that depend on livestock and rain-fed agriculture. The population resident along the river, not included in the study, was excluded from the sample frame. The sampling frame also excluded settlements with more than 2000 inhabitants, because the focus was on rural households.

To select sample villages from this frame, geographic strata reflecting populations facing different climatic conditions were created. The northern sub-zone was defined as the two more arid departments of Matam and Kanel. Bakel and Goudiry constitute the more humid southern sub-zone. These sub-zones

created the two strata from which villages were randomly selected in numbers proportional to their populations.

Given the exclusions noted above, the total survey population was 137,908, with 65,477 people (47.4 percent) in the northern sub-zone, and 72,431 people (52.6 percent) living in the southern sub-zone. Based on the size of these populations as well as logistic limitations of implementing the survey, a total of 15 villages were selected. Thus, following the proportions of the survey populations of the two strata, the ArcGIS Sampling Design Tool was used to select seven villages from the north and eight from the south. The process included a rule that villages be at a minimum of 10 kilometers from one another in order to prevent contiguous villages from being selected and adequate geographic distribution. An additional seven villages, three from the northern zone and four from the southern zone, were selected as replacements in case the initially selected villages proved inaccessible or were otherwise disqualified. (See Table 2 on the previous page. A complete description of the process may be found in Annex E, "Draft report on selection of survey villages".)

Because intra-village variation was expected to be greater than differences between villages, 30 households, a relatively large number, were surveyed in each village. For villages with fewer than 30 households, the next nearest village was included in the sample.

Survey and focus group implementation

An initial trip to contact villages was conducted from October 21 to 28, 2013. During these initial contacts the purpose, timing, and nature of the fieldwork was explained, and basic information was collected concerning each village and department. At this point, two villages were excluded because they were found to be inaccessible, and were replaced by two villages from those identified for this purpose. (For more information, see Annex F, "*Rapport de mission sur la prise de contact et la prospection des villages retenus pour l'étude*").

During the week of November 11, the ARCC assessment team trained 12 enumerators, two supervisors, and four facilitators to conduct the survey and focus groups. Trainees piloted the instruments on November 16 and completed fieldwork on December 5. Two days were allotted for each of the 15 survey villages, and in a number of instances the teams spent the night in the village.

Upon arriving in each village, supervisors of the fieldwork teams conducted introductory meetings with village chiefs, notables, and other interested parties, during which the purpose of the research as well as the timing and organization of the interviews and focus groups were explained. At this point they also collected and completed lists of the village households. Six of the original 15 villages — three in the northern sub-zone and three in the south — had fewer than 30 households, and households and focus group participants were added from an additional six neighboring villages. Once the total population was defined for each location, 30 households were randomly selected from the total list by village members drawing names from a hat.

Interviews were conducted with household heads at their residence using Iform Builder software on Apple tablets. Supervisors attended interviews and reviewed results on tablets. Each evening results were uploaded to the ARCC website for further review both by the supervisors and by other members of the assessment team.

Focus groups were conducted concurrently with the surveys. Supervisors explained that participants in the men's and women's focus groups should be adults who know the village and represent the diversity of the village, coming from its various neighborhoods, ethnic groups, livelihood groups, and wealth categories. Handwritten notes from each focus group were drafted into reporting forms on laptops in

the evening or the following day. A total of 421 people participated in the focus group discussions, 207 of whom were men, and 214 of whom were women.

KEY INFORMANT INTERVIEWS AND ANALYSIS: THE INSTITUTIONAL CONTEXT

External institutions are critical to the ability of local communities to contend with climate change because of the important role they play in shaping and strengthening adaptive capacity. In preparation for the key informant interviews, ARCC subcontractor WRI was asked to draft a desktop study of available literature on the topic of institutional responses to climate variability and change in Senegal. This document was conceived as the first portion of a report to be completed through analysis of the key informant interview results. Completed in July 2012, this literature review informed the design of the key informant interview instruments. This review, as well as interviews conducted during the initial scoping mission, suggested that national government efforts to address climate change have yet to have a direct impact in the study zone. For this reason, the key informant institutional interviews were conducted at the regional level and below with staff of the institutions that have had the most direct contact with the communities of the study zone.

TABLE 3: KEY INFORMANT INTERVIEWS CONDUCTED

	Matam	Kanel	Bakel	Goudiry	Total
Technical Service	3	2	2	1	8
Rural Council	4	3	2	5	14
Project	2	1	2	2	7
Trader	4	2	3	2	11
Total	13	8	9	10	40

To conduct the interviews, a two person team contacted key persons at the regional, departmental, and local level (*communauté rurale*) to learn about the mandates and capacities of institutions in supporting local communities and crop-based and livestock based production systems in the management of climate shocks and trends. Questions addressed demonstrated institutional capacity, awareness, and planning regarding climate events, whether perceived as natural or anthropogenic. Interview instruments were developed in collaboration with WRI and ISRA/BAME staff. Interviews were conducted by ISRA/BAME staff. (Complete final questionnaires are found in Annex C.)

A total of 40 interviews were conducted. In each of the four departments, the team conducted interviews with representatives of projects working in the domain of agriculture/livestock, as well as representatives of governmental technical services (principally agriculture and livestock husbandry) and a department-level trader in livestock or grains. At the rural community level, the team interviewed staff and representatives of the rural council and a trader in a local market (see Table 3),

Key informant interviews began on November 16 and concluded on December 4.

CLIMATE DATA AND METHODS

Current Climate

The selection of station data used in the analysis was based on availability and proximity. Current climate and its variability in the study zone has been described using *in-situ* observations of rainfall, maximum and minimum temperature, relative humidity, insolation, and wind from five stations (Tambaconda, Bakel,

Goudiry, Matam, and Bakel). ISRA analyzed and made available archives of monthly records of those variables for the period 1970–2010, as well as daily records of rainfall covering most of the period.

In order to reveal larger trends "hidden" in patterns that follow daily, yearly, and decadal cycles, rainfall data was pooled into two periods, one spanning from 1970 to 1990 and a second from 1990 to 2010. These periods were selected because they bracket two distinct rainfall periods previously observed in the Sahel, in Senegal, and in the annual data for the study zone. Annual rainfall in first 20-year period was, on average, dryer than the second. Analyses of this station data documented long-term changes in average rainfall, temperature, relative humidity, insolation, and wind. It also provided context for projections.

Future Climate

Projections of future climate conditions for the horizons of 2030 and 2050 used outputs of 10 different models of varying resolutions from the latest archive of climate projections, Coupled Model Intercomparison Project Phase 5 (CMIP5) under two emission scenarios (Representative Concentration Pathway [RCP] 4.5, akin to the current emission level and RCP8.5, an increased emission level). To document the range of possible changes, results of models that produced the driest, wettest, and average (closest to the multimodel average) projections were selected for each emission scenario and time horizon. As noted above, station data were used to downscale model outputs and provide geographic and amplitude bias-correction.

MODELING OF DROUGHT IMPACT ON LIVESTOCK

Demography is a key determinant of the dynamics of livestock herds in tropical traditional husbandry systems such as those of the assessment zone. Demographic models are particularly useful to study the effects of environmental factors on herd dynamics. ARCC, in collaboration with ISRA/LNPRV, planned to use one such model to examine the potential impact of an increased frequency of drought on livestock populations – mm-age, a demographic model developed by the French agricultural research center CIRAD (Lesnoff, 2012).

Data were collected during four day-long workshops conducted in the four departmental capitals of the study zone in the final days of August 2013. A total of 44 persons were interviewed. Through these group interviews with experienced herders and government technical service representatives, data were collected on the average demographics of herds (proportion cattle/small ruminants, proportion male/female, distribution by age, rates of mortality, and reproduction) as well as herd management decisions (rates of slaughter, gifting, purchase, and sales). Herders were also interviewed on the historical impact of drought, rainfall, and temperature on their herds. Participants were allowed to use a local definition of drought, which generally corresponded with scientific records of droughts in the region.

The model mm-age uses management decisions regarding the intake and offtake of animals to simulate herd dynamics. Workshop scenarios focused on how additional droughts in a 10-year period would impact intake and offtake for cattle and small ruminants. (The research design proposed that each workshop discuss the impact of up to three additional droughts every 10 years; however, because participants considered the addition of three additional droughts to be catastrophic, this hypothetical scenario was not presented, and related data was not collected.)

In addition to exploring the number of years required for herd population to recover after one drought per decade, this work also modeled the impact of decadal drought on the cattle to small ruminant ratio.

It should be noted that this model was used in an exploratory manner. Researchers have not extensively used and tested mm-age's application in the projection of climate change impacts beyond the simulation of climate shocks on livestock populations that Lesnoff, Corniaux, and Hiernaux (2012) conducted. Their modeling exercise utilized secondary literature on regional livestock dynamics to create parameters for the model. The modelers at ISRA used their expertise in the R modeling platform to learn and execute the mm-age application. When it was found that government sources lacked the necessary data, data collection through interviews with experienced herders was viewed as the best approach given existing time constraints. A systematic mm-age exercise would have required an extensive, survey-based data collection effort as described in Lesnoff (2011). Since such an effort fell outside the scope of the project, this activity was intended to build awareness and capacity within ISRA from the onset and its results indicative.

TABLE 4: YEARS SELECTED FOR HISTORICAL SIMULATIONS

Driest Years		Average Years		Wettest Years	
1984	1977	1987	1979	1988	1981
2002	1992	1998	1995	2003	1994

Once the data had been collected and cleaned, the ISRA team produced an initial report on the results of modeling. Upon review of the initial report, ARCC decided to discontinue the activity. In the end, the ISRA team was unable to produce a complete and reliable analysis. Results of the modeling work have not been used in the final assessment report.

MODELING OF CLIMATE IMPACT ON LIVESTOCK RESOURCES

The assessment includes a second livestock modeling exercise. This study explores the impact of climate change on the natural resources upon which livestock depend in the study zone, principally pasture, water points, and crop residue. Using the same set of climate data as used in the crop modeling activity, it projects changes in the carrying capacity of the project zone for the years 2030 and 2050. Core to this work was modeling the evolution of natural vegetation with the STEP model, which uses daily rainfall and temperature data and soil characteristics to simulate the main relevant processes associated with herbal functioning and soil-water dynamics in the Sahelian environment. Crop residue projections were based on the results of the crop process modeling described below. Hydrological modeling was based on the relationship between rainfall, herd size, and the dates on which principal water points are exhausted. As with the modeling of the impact of drought on herds described above, this approach is innovative in the climate change context. Results were qualified and contain a level of uncertainty.

LITERATURE REVIEW AND EXPERT ANALYSIS: POTENTIAL IMPACT OF CLIMATE CHANGE ON LIVESTOCK DISEASES

This review of the scientific literature summarizes the state of knowledge regarding the most important diseases afflicting livestock in Senegal. It analyzes potential climate change impacts on the more common and problematic diseases in addition to describing the environmental and management factors that affect infection and transmission of each disease. It further outlines likely changes in their distribution and severity and, ultimately, damage to livestock. Valuable as an independent product, this study also has been used to enrich the understanding of current livestock management challenges and opportunities explored in the assessment. It can also be used in conjunction with resource modeling to produce a broader understanding of the potential impact of climate change on livestock husbandry in the study zone.

LITERATURE REVIEW: CROP PHENOLOGY PROFILES AND POTENTIAL PEST AND DISEASE IMPACT ON CROPS

This study reviews existing literature on the agronomy and phenology of the principal crops grown in the study zone. It summarizes the relevant characteristics of each crop to produce a rough depiction of the crop's climatic production parameters by phenological stage. It then uses a rough characterization of future climate, based on annual average temperature and precipitation, to derive potential impacts of climate change on the productivity of those crops. The team recognizes that a wide range of factors in addition to mean annual temperature and rainfall affect the productivity of crops; these include soil characteristics, the intra-seasonal distribution of rainfall and temperature, farmer management practices, and seed variety. Nevertheless, in this assessment the team proposes that the characteristics of different crops are distinct enough that this method can be used to establish the relative vulnerability of the various principal crops grown in the study zone.

To estimate impact, the profiles are based on worst-case assumptions concerning future climatic conditions by 2100. For the departments of Matam and Kanel, the team assumes a mean increase of 2.35 °C in the minimum normal temperature and a 2.0 °C increase in the maximum temperature. In Goudiry and Bakel, we assume a mean increase in the minimum normal temperature of 2.2 °C and a 1.9 °C increase in the maximum temperature. Regarding annual rainfall, we assume a decrease to 424 mm (-16 percent) in the North and a decrease to 631 mm (-11 percent) in the South.

The same document also explores, for each crop, the potential impact of increasing temperature and decreasing rainfall on the pests and diseases that afflict them. The results inform the description of current crop systems and the crop modeling activity.

MODELING OF CLIMATE IMPACT ON CROPS

To explore current climate threats to and potential future exposure of households depending on specific crops, projections of the direct impacts of changing climatic conditions on crop productivity were produced using the CropWat model (FAO, 2013). Developed by FAO, this model relates crop yields to a plant's water requirements based on prevailing meteorological conditions (temperature, humidity, solar radiation, and wind); soil characteristics; crop development stages; and farming. To evaluate the sensitivity of crops to changes in the conditions of the study zone, ISRA simulated the performance of the crops using observed meteorological data for the driest, average, and wettest years for each of the two periods, the dryer 1971–1990 period and the wetter 1991–2010 period.

Similar to the historical simulations, modeling of future changes in crop production used projections of metrological data pooled into 20-year periods, one centered on 2030 (2020–2040) and one centered on 2050 (2040–2060). From projections, driest, average, and wettest years were selected for CropWat modeling. (Note: projections of climate change impacts on crop and biomass production used the same approach. Dry, normal, and wet year projected climate data served as inputs for modeling to time horizons to again indicate the range of potential changes.)

Because the available data is insufficient to reliably interpolate between stations, available data from two or three stations have been used to illustrate climatic conditions found in each sub-zone.

Modeling was conducted for the most widespread varieties of millet, sorghum, maize, cowpea, groundnut, and rice. Parameters for the characteristics of these varieties, such as root growth and the duration of each phenological phase, were drawn from data based on local research; gaps were filled using the FAO database.

LITERATURE REVIEW AND SPATIAL ANALYSIS: THE ROLE OF MARKETS

Limited market access increases the vulnerability of rural households by lowering the sale price of produce and raising the purchase price of needed goods. It constrains the accumulation of capital for use in times of stress while limiting the potential to address local shortages through the use of stored wealth. ISRA and CSE undertook two studies to examine the role of markets in the vulnerability of households in the study zone.

The CSE study, based on available literature and spatial data, focuses on the potential impact of climate change on market access especially in terms of the likely impact on transportation routes. A spatial analysis of market access in the study zone complemented a literature review. The review and mapping describe the type and characteristics of the markets in eastern Senegal with particular attention given to the impact on food insecurity.

The ISRA study reviews the available literature describing the conditions under which markets serve as a means to achieve household food security and those under which they serve as a source of vulnerability. It attempts to identify, in particular, the potential role of climate in this relationship. Using limited local data, the study proposes a framework for looking at how, given the current market system in the study zone, climate may increase the vulnerability of households; it also proposes opportunities to reduce this vulnerability.

LITERATURE REVIEW AND EXPERT ANALYSIS: OPPORTUNITIES AND BARRIERS IN RESEARCH AND EXTENSION

In preparation for the options analysis phase of the Senegal assessment, ISRA has conducted a review of the history and current status of agricultural development in Senegal, focusing on efforts to strengthen livestock and agriculture systems in the eastern portion of the country. Based on literature and the experience of ISRA staff and colleagues, the report provides a context for the process of identifying options to address the vulnerabilities identified in the study zone.

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ANNEX B1. COMPUTATION OF THE INDEXES IN THE HOUSEHOLD ANALYSIS

Education Score

This is a household-level index used to measure household "commitment" or "investment" in household member education. We realize that educational systems change and that an older generation has different formal education opportunities than do younger ones.

1. Select only the members of the household above six years of age.
2. If the household member has no education, a score of "0" is attributed.
3. If a household member between seven and 12 years of age is in primary school or finished primary school, a "1" is attributed.
4. If a household member is between 13 and 18 years of age and has either finished primary school, is attending secondary school, or finished secondary school, a "1" is attributed.
5. If a household member is older than 18 years of age and has at least finished primary school, a "1" is attributed.

Every household member older than six years of age is attributed either a "1" or a "0"; thus, the average for the household is between 0 and 1 and is a unique score.

Asset Score

The asset list includes all items in the question asset list plus traction animals (plough animals). The smallest valued asset (hoe/rake) is attributed a "1". The other assets are then valued in terms of the smallest size. For example, a bicycle is attributed 200 units. The total sum then becomes the asset score.

```
COMPUTE GRAN_VAL=Granary*200.

COMPUTE FENC_VAL=Fencing*200.

COMPUTE SPRAY_VAL=Sprayer*6.

COMPUTE MILL_VAL=Milling*18.

COMPUTE PUMP_VAL=Irrigation_pump*300.

COMPUTE BOAT_VAL=Boat*200.

COMPUTE HOE_VAL=Hoe.

COMPUTE PLOW_VAL=Plow*18.

COMPUTE TRACTOR_VAL=Tractor*1000.

COMPUTE SHOVEL_VAL=Shovel*6.

COMPUTE LARGE_HOE_VAL=Large hoe*6.

COMPUTE MACHETE_VAL=Machete*6.

COMPUTE SEEDER_VAL=Seeder*6.
```

```
COMPUTE AXE_VAL=Axe*6.
COMPUTE SICKLE_VAL=Sickle*6.
COMPUTE WESTERN_HOE_VAL=Western_hoe*6.
COMPUTE HAND_HOE_VAL=Hand_hoe*1.
COMPUTE MOTOCYCLE_VAL=Motorcycle*300.
COMPUTE BICYCLE _VAL=Bicycle*200.
COMPUTE CART_VAL=Cart*18.
COMPUTE TRUCK_VAL=Truck*1000.
COMPUTE CAR_VAL=Car*1000.
COMPUTE RADIO_VAL=Radio*6.
COMPUTE DVD_PLAYER_VAL=DVD_player*36.
COMPUTE CELLPHONE_VAL=Cellphone*6.
COMPUTE REFRIGERATOR_VAL=Refrigerator*150.
COMPUTE DINING_TABLE_VAL=Dining_table*18.
COMPUTE CHAIRS_VAL=Chairs*18.
COMPUTE WHEEL_BARROW_VAL=Wheel_barrow*18.
COMPUTE KNIFE_VAL=Knife.
COMPUTE NEWHOE_VAL=NEWHOE*6.
COMPUTE FORGE_VAL=Forge*36.
COMPUTE PLANT_STICK_VAL=Plant_stick.
COMPUTE PICK_VAL=Pick*6.
COMPUTE RAKE_VAL=Rake*6.
COMPUTE SMALL_TOOL_VAL=Small_tool*6.
COMPUTE PLOUGH_VAL=TOT_HHPLOUGH*200
```

Food Consumption Score (FCS)

This is a universally accepted measure of diet quality and diet diversity. Weights are attributed to seven food groups. Since this is seven-day recall, each household will have consumed a given food group between 0 and 21 times. The food groups and weights are expressed as follows:

```
COMPUTE DIET_SENEGAL=(Cereal+Tubers)*2 + (Leafy_veggies + Other_veggies + Orange_fruits) +
(Pulses*3) + (Meat + Eggs + Fish + Milk)*4 +(Oils_fats+Sugar)*.5.
```

- Cereals and tubers have a weight of 3

- Leafy veggies and tubers have a weight of 2
- Pulses are 3; protein sources are 4
- Oils, fats, and sugars are 4
- Measure is the weighted sum

Index on Diversity of Income

This index is derived from the income section of the questionnaire. It comprises a long list of income source variables to which a value of "0" or "0-25", "25-50", and ">75" is attributed. A dummy variable was created for each income source variable that carries a value of "0" or "1" (if the corresponding variable above is >0). The household variable on diversity is created by summing across the dummy variables, giving an answer between 0 and the maximum number of sources.

A climate-neutral diversity was created by summing across those income sources that are not influences by climate (professional, skilled, remittances).

Social Capital Index

This index is based on the assumption that social capital can be measured by the density of giving and receiving in which a household engages. Thus, a variable was created for every type of giving (money, food, etc.) times the annual frequency of giving events. These were then summed across each giving type. A second variable was created for receiving, in which each type of source (friends/neighbors, relatives) times the frequency of the receiving was calculated as an annual value. These annual receiving events (by source) were summed to produce a receiving variable. The receiving and giving levels were summed to arrive at a total level of exchange events, i.e., the social capital index.

External Dependence Index

This index was calculated exactly as the receiving variable above, except the sources included in the calculation were NGOs, government, the United Nations, and others.

ANNEX C. HOUSEHOLD SURVEY QUESTIONNAIRE

Page de Garde

Record: 1399	
NOM DU VILLAGE	*Samba Kolo*
Village name	*Samba Kolo*
NOM DU DÉPARTEMENT	*BAKEL*
NOM DU CR	*Sinthiou Fissa*
Est-ce que ce village a moins de 30 menages?	*Non*
IDENTITÉ MENAGE	*ARCC-1399*
NOM DE L'ENQUÊTEUR	*Amadou Diallo*
COORDONÉES GPS	*Latitude:14.223051, Longitude:-12.380942, Altitude:81.139084, Vitesse:0.000000, Précision horizontale:5.000000, Précision verticale:9.500000, Temps:10:46:34 AM GMT*
DATE	*2013-12-05*
HEURE DE DÉMARRAGE	*10:47:00*
NOM DE LA PERSONNE INTERROGÉE	*Kadidia Sow*
STATUT DE LA PERSONNE INTERROGÉE	*Conjoint du Chef de famille*
RELIGION	*Musulman*
GROUPE ETHNIQUE	*Peul*
HEURE FIN ENQUETE	*11:42:00*

2a. MEMBRES DU MÉNAGE	
Nom	*Hadidia Sow*
Relation avec le chef de famille	*Epoux/Epouse*
Sexe	*Féminin*
Âge	*18*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux domestiques du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Hamady Samba Diallo*
Relation avec le chef de famille	*Chef*
Sexe	*Masculin*
Âge	*50*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux agricoles du ménage*
Occupation secondaire dernier 12 mois	*Aucune activité*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Moussa Diallo*
Relation avec le chef de famille	*Frère ou sœur*
Sexe	*Masculin*
Âge	*40*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux agricoles du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Demba Diallo*
Relation avec le chef de famille	*Frère ou sœur*
Sexe	*Masculin*
Âge	*30*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux agricoles du ménage*
Occupation secondaire dernier 12 mois	*Petit commerce*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Adama Diallo*
Relation avec le chef de famille	*Frère ou sœur*
Sexe	*Masculin*
Âge	*20*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux agricoles du ménage*
Occupation secondaire dernier 12 mois	*Aucune activité*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Korka Ba*
Relation avec le chef de famille	*Epoux/Epouse*
Sexe	*Féminin*
Âge	*40*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux domestiques du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Haby Dia*
Relation avec le chef de famille	*Epoux/Epouse*
Sexe	*Féminin*
Âge	*20*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux domestiques du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Cira Soumare*
Relation avec le chef de famille	*Autres à préciser*
Autres à préciser	*Epouse du chef de menage*
Sexe	*Féminin*
Âge	*20*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux domestiques du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Kadia Kane*
Relation avec le chef de famille	*Autres à préciser*
Autres à préciser	*Epouse du frere du chef de menage*
Sexe	*Féminin*
Âge	*20*
État civil	*Marié(e)*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux domestiques du ménage*
Occupation secondaire dernier 12 mois	*Travaux agricoles du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Oumar Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Masculin*
Âge	*15*
État civil	*Célibataire*
Niveau d'éducation	*Aucun*
Occupation principale dernier 12 mois	*Travaux agricoles du ménage*
Occupation secondaire dernier 12 mois	*Aucune activité*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Diary Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*16*
État civil	*Célibataire*
Niveau d'éducation	*Primaire incomplet*
Occupation principale dernier 12 mois	*Eleve/Etudiant*
Occupation secondaire dernier 12 mois	*Travaux domestiques du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Rougui Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*10*
Niveau d'éducation	*Primaire incomplet*
Occupation principale dernier 12 mois	*Eleve/Etudiant*
Occupation secondaire dernier 12 mois	*Travaux domestiques du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Maimouna Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*9*
Niveau d'éducation	*Primaire incomplet*
Occupation principale dernier 12 mois	*Eleve/Etudiant*
Occupation secondaire dernier 12 mois	*Travaux domestiques du ménage*
Migration/Transhumance dans les 12 derniers mois	*Ni migration ni transhumance*

2a. MEMBRES DU MÉNAGE	
Nom	*Mady Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*6*

2a. MEMBRES DU MÉNAGE	
Nom	*Oumou Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*5*

2a. MEMBRES DU MÉNAGE	
Nom	*Oumou Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*4*

2a. MEMBRES DU MÉNAGE	
Nom	*Aissata Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Féminin*
Âge	*3*

2a. MEMBRES DU MÉNAGE	
Nom	*Alassane Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Masculin*
Âge	*2*

2a. MEMBRES DU MÉNAGE	
Nom	*Mansour Diallo*
Relation avec le chef de famille	*Nièce/Neveu*
Sexe	*Masculin*
Âge	*2*

2a. MEMBRES DU MÉNAGE	
Nom	*Amadou Diallo*
Relation avec le chef de famille	*Enfant*
Sexe	*Masculin*
Âge	*2*

3a. Champs contrôlé ou exploite par les hommes (10 dernières années)	
Champs	*1*
Type de Champs	*diery*
Superficie	*1.5*
Unite de surface	*Hectare*
Cultures Principale - 1	*Mil*
Cultures Principale - 2	*Neant*
Cultures Principale - 3	*Neant*
Type de régime foncier	*Propriétaire*
Nbre d'Ans que ce champs a eté cultivé	*10*

3a. Champs contrôlé ou exploite par les hommes (10 dernières années)	
Champs	*2*
Type de Champs	*diery*
Superficie	*1*
Unite de surface	*Hectare*
Cultures Principale - 1	*Maïs*
Cultures Principale - 2	*Neant*
Cultures Principale - 3	*Neant*
Type de régime foncier	*Propriétaire*
Nbre d'Ans que ce champs a eté cultivé	*10*

3a. Champs contrôlé ou exploite par les hommes (10 dernières années)	
Champs	*3*
Type de Champs	*diery*
Superficie	*1*
Unite de surface	*Hectare*
Cultures Principale - 1	*Arachides*
Cultures Principale - 2	*Neant*
Cultures Principale - 3	*Neant*
Type de régime foncier	*Propriétaire*
Nbre d'Ans que ce champs a eté cultivé	*10*

3b. Champs contrôlé ou exploite par les femmes (10 dernières années)	
Champs	*0*

3c. Changements des resources en terre (menage)	
Changements dans le superficie	*Même*
Terre suffisance?	*Avait besoin de plus*

3d. Cultures produites par le ménage l'année dernière	
Produit Cultivé	*Mil*
Quantité	*12*
Unité	*Charrette*
Quantité Vendue: Qté	*0*
Quantité Vendue: Unité	*Kilo*
Valeur en CFA	*0*
Changement du Niveau de Production des Principales Cultures (10 dernières années)	*Moins de Production*
Ampleur du Changement	*0-25%*
Raison	*Autres à préciser*
Autres à préciser	*Defaut d engrais*

3d. Cultures produites par le ménage l'année dernière	
Produit Cultivé	*Maïs*
Quantité	*6*
Unité	*Charrette*
Quantité Vendue: Qté	*0*
Quantité Vendue: Unité	*Kilo*
Valeur en CFA	*0*
Changement du Niveau de Production des Principales Cultures (10 dernières années)	*Aucun changement*
Raison	*Autres à préciser*
Autres à préciser	*Aucun probleme*

3d. Cultures produites par le ménage l'année dernière	
Produit Cultivé	*Arachides*
Quantité	*10*
Unité	*Sac de 50 Kg*
Quantité Vendue: Qté	*0*
Quantité Vendue: Unité	*Kilo*
Valeur en CFA	*0*
Changement du Niveau de Production des Principales Cultures (10 dernières années)	*Moins de Production*
Ampleur du Changement	*26-50%*
Raison	*Autres à préciser*
Autres à préciser	*Defaut d engrais et qualite du sol*

3e. Bétail appartenant aux hommes	
Type de bétail	*Bovin*
Taille actuelle du tropeau present dans le menage	*20*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3e. Bétail appartenant aux hommes	
Type de bétail	*Moutons*
Taille actuelle du tropeau present dans le menage	*1*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3e. Bétail appartenant aux hommes	
Type de bétail	*Anes/Mulets*
Taille actuelle du tropeau present dans le menage	*2*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3e. Bétail appartenant aux hommes	
Type de bétail	*Chevaux*
Taille actuelle du tropeau present dans le menage	*2*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3e. Bétail appartenant aux hommes	
Type de bétail	*Chevres*
Taille actuelle du tropeau present dans le menage	*5*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3f. Bétail appartenant aux femmes	
Type de bétail	*Bovin*
Taille actuelle du tropeau present dans le menage	*10*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*0*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*0*
Changement de taille du troupeau (10 dernières années)	*Aucun changement*

3f. Bétail appartenant aux femmes	
Type de bétail	*Volaille*
Taille actuelle du tropeau present dans le menage	*5*
Gerés par d'autres en dehors du menage	*0*
Animaux des autres gardé par le menage	*0*
Perdus 12 derniers mois	*0*
Morts 12 derniers mois	*5*
Volés 12 derniers mois	*0*
Vendus ces 12 derniers mois	*8*
Changement de taille du troupeau (10 dernières années)	*Troupeau diminué*
Magnitude de Changement	*plus de 50%*
Raison	*Autre à preciser*
Autres à préciser	*Mort de maladie et vente*

3g. Vente de produits du bétail pendant les 12 derniers mois (menage)	
Lait: Produire?	*Oui*
Lait: Vendre?	*Non*
Fromage: Produire?	*Non*
Fromage: Vendre?	*Non*
Yaourt (lait caillé): Produire?	*Non*
Yaourt (lait caillé): Vendre?	*Non*
Babeurre: Produire?	*Non*
Babeurre: Vendre?	*Non*
Huile de beurre: Produire?	*Non*
Huile de beurre: Vendre?	*Non*
Œufs: Produire?	*Non*
Œufs: Vendre?	*Non*
Peaux/cuirs: Produire?	*Non*
Peaux/cuirs: Vendre?	*Non*
Fumier: Produire?	*Non*
Fumier: Vendre?	*Non*

3h. Pratiques de gestion du bétail (menage)	
Types d'aliments achetés	*Tourteau d'arachide, Graines de cotton, Ripas*
Payez-vous quelqu'un pour élever ou gérer vos troupeaux?	*Non*
Où gardez-vous vos troupeaux pendant la saison pluvieuse?	*Dans le village*
Distance de votre camp/village par rapport au lieu de garde durant la saison pluvieuse	*0-10km*
Où gardez-vous vos troupeaux pendant la saison sèche?	*Dans le village*
Distance de votre camp/village par rapport au lieu de garde durant la saison sèche	*0-10km*
Distance entre les destinations de la saison des pluies et la saison sèche (km)	*0-10km*
Vaccinez-vous vos animaux	*Oui*
Avez-vous recours à d'autre services vétérinaire	*Non*
Dans la dernière année, un membre de votre famille a-t-il été refusé l'accès aux terres cultivables, eau, arbres, pâturages, ou d'autres ressources naturelles dont ils ont dépendu dans le passé?	*Non*

4a. Biens (menage)	
Greniers ou magasins pour les céréales	*0*
Parc/Enclos/Écurie	*3*
Pulvérisateur	*0*
Broyeur/moulin	*0*
Pompe d'irrigation	*0*
Pirogue	*0*
Houe	*0*
Charrue	*1*
Tracteur	*0*
Pelles	*1*
Hilaire	*0*
Machette/coupe-coupe	*2*
Semoire	*1*
Hache	*2*
Faucille/sarte	*1*
houe occidental	*0*
houe sine	*0*
Autres à préciser?	*Non*
Mobylette/Moto	*0*
Vélo	*1*
Charette	*1*
Camion/Camionnette	*0*
Voiture	*0*
Radio	*0*
Télévision/Lecteur DVD	*0*
Téléphone cellulaire	*1*
Réfrigérateur	*0*
Meubles: Table	*0*
Meubles: Chaises	*0*

4b. Logement	
Principaux matériaux du logement: murs	*Argile bois*
Principaux matériaux du logement: plancher	*Terre/argile*
Principaux matériaux du toit	*Chaume/bois*
Électricité	*Autres à préciser*
Électricité: Autres à préciser	*Lampe torche*
Robinet dans le menage	*Non*

5a. Participation pendant les 12 derniers mois	
Association de producteurs	*Non*
Association d'éleveurs	*Non*
Travaux collectifs	*Non*
Banque de semences	*Non*
Groupes d'âge (même génération)	*Non*
Clubs sportifs (ASC, Nawétanes)	*Non*
Groupe d'épargne solidaire/Tontine	*Non*
Comité scolaire	*Non*
Autre type d'association	*Non*

5b.1 Solidarité sociale pendant les 12 derniers mois - Aide reçue	
Amis/Voisin	*Non*
Parents	*Non*
ONG/Projet	*Non*
Gouvernement	*Non*
Agence des Nations Unies	*Non*
Autres à préciser	*Non*

5b.2 Solidarité sociale pendant les 12 derniers mois - Don	
Partage de nourriture	*Non*
Argent	*Non*
Vêtements	*Non*
Outils	*Non*
Semences	*Non*
Animaux de Traction	*Non*
Autres à préciser	*Non*

6a. Activités génératrices de revenus pendant les 12 derniers mois	
Travaux agricoles du ménage	*0*
Travaux d'élevage du ménage	*entre 1/2 et 1/4*
Travaux domestiques du ménage	*0*
Travaux agricoles pour d'autres	*0*
Travaux d'élevage pour d'autres	*0*
Travail non qualifié pour d'autres (manœuvre)	*0*
Travail qualifié (maçon, menuisier, mécanicien)	*0*
Professionnel salarié	*0*
Extraction de ressources naturelles (bois/charbon)	*0*
Artisanat	*0*
Petit commerce	*entre 1/2 et 1/4*
Marabout	*0*
Pêche/vente de poissons	*0*
Provenant de l'exode ou de l'emigration	*0*

6b. Épargne	
Un membre du ménage qui participe au groupe d'épargne	*Non*
Un membre du ménage qui appartient au groupe de crédit en rotation (tontine)	*Non*
Un membre du ménage qui a un compte bancaire	*Non*

7a. Mois d'insécurité alimentaire pendant les 12 derniers mois	
Cochez les mois pendant lesquels vous avez consommé les aliments que vouz avez produit?	*JAN, FÉV, MARS, NOV, DÉC*
Quels sont les mois où vous avez l'insuffisance de nourriture malgré les revenus des activités agricoles et extra agricoles?	*MARS, AVR, MAI, JUIN, JUIL, AOÛT, SEP, OCT*
Sècheresse (Nbre d'années)	*0*
Inondation (Nbre d'années)	*0*
Avez-vous actuellement des semences stockées pour la prochaine campagne agricole?	*Oui*

7b. Régime alimentaire diversifié	
Céréales : y compris riz, pain, maïs, sorgho, fonio, mil	*21*
Tubercules : y compris patate douce, manioc, pomme de terre	*4*
Tous les légumes à feuilles vert foncé, y compris les feuilles de manioc, les feuilles de baobab, les feuilles de bissap, etc.	*3*
Tous les autres légumes, y compris gombo, aubergine amère, laitue, oignon, concombre, poivron, haricots verts, chou	*3*
Les fruits jaunes ou orange à l'intérieur, y compris papaye, mangue, etc.	*0*
Autres fruits, y compris banane, agrumes, melon, tomate, dattes, baobab (bouye), etc.	*2*
Toute viande, y compris bœuf, l'agneau, le poulet, la viande de brousse	*1*
Les œufs	*0*
Poissons frais ou séchés	*2*
Les légumineuses et les légumes secs notamment niébé, haricots, arachides, pois	*4*
Lait ou les produits laitiers, y compris yaourt, fromage, beurre, etc.	*3*
Huile, graisse	*7*
Le sucre, le miel	*15*
Le café, le thé	*15*
Toutes les collations ou aliments achetés en dehors de la maison, comme les boissons gazeuses, les gâteaux	*0*

8a. Eau, Assainissement et Santé (menage)	
Certains hommes et femmes de la famille sont-ils chroniquement malades ? (Tombent-ils malades très souvent)?	*Oui*
Quelqu'un dans la famille a-t-il été tellement malade qu'il a dû s'absenter du travail au cours des quatre dernières semaines?	*Non*
D'où obtenez-vous le plus souvent l'eau potable? Saison pluvieuse	*Pompe/robinet de village*
D'où obtenez-vous le plus souvent l'eau potable? Saison sèche	*Pompe/robinet de village*
Quelle est la distance entre la source d'eau potable et e votre lieu de résidence pendant la saison sèche? Temps de marche (heures)	*0*

ANNEX D. FOCUS GROUP GUIDE

VULNÉRABILITÉ AU CHANGEMENT CLIMATIQUE DANS L'EST DU SÉNÉGAL

Support 1. GUIDE DE DISCUSSIONS EN FOCUS GROUPE

Introduction:

ISRA organisera une série de discussions en focus groupe (DFG) dans les mêmes communautés que celles de l'échantillon de l'enquête auprès des ménages. Dans chaque communauté, deux groupes de discussions thématiques, l'un avec des hommes adultes et l'autre avec des femmes adultes, porteront sur les stratégies et les pratiques utilisées en réponse à la variabilité du climat et l'occurrence d'événements extrêmes. Les origines de ces réponses adaptatives ainsi que les contraintes à l'adoption de stratégies efficaces seront également explorées. Pour des raisons de représentativité au village, les groupes de discussions seront composés de ménages qui pratiquent différentes stratégies de moyens d'existence dans la communauté.

Processus :

1. Chaque groupe d'hommes et de femmes sera composé de 15 personnes au maximum. Chaque participant doit être un adulte et avoir vécu au village depuis 10-20 ans au moins. Dans les villages avec de multiples moyens de subsistance, les représentants des différents groupes devraient être inclus. Les participants doivent être choisis dans tous les quartiers, les clans, les castes et les groupes religieux dans le village pour s'assurer qu'il y a une représentation adéquate. Le processus de sélection sera probablement négocié avec le chef de village après avoir expliqué le but de la DFG et les paramètres de la représentation.

2. Les groupes de discussion seront animés par une équipe de deux personnes : un homme et une femme. Si le groupe de discussion est composé d'hommes, l'homme sera l'animateur et la femme servira de rapporteur, et vice versa.

3. Pendant la réunion de présentation avec les responsables[1] du village, le superviseur de l'équipe présentera les membres de l'équipe et fournira une explication sur l'objet de l'étude, les participants à l'étude et comment la visite sera conduite, une fois l'autorisation accordée. Toutes les exigences de confidentialité et de consentement éclairé des « sujets humains » seront décrites dans le cadre du processus d'obtention de l'autorisation.

4. Au cours de la formation et les discussions de groupe eux-mêmes, il est important de souligner que le groupe est invité à parler du village dans son ensemble et non pas leurs propres situations individuelles. Un participant peut utiliser son / sa propre situation, par exemple, mais la discussion est destiné à identifier les caractéristiques courantes du village pas que de chaque participant. L'animateur doit eviter que la parole soit monopolisée par un ou quelques individus. Il doit encourager la participation effective de tous les membres du groupe. Un indicateur-cle de la reussite d un focus est le niveau de refléction generée entre les differents membres du groupe.

[1] Il est entendu que la «réunion du village » peut avoir lieu avant l'arrivée de l'équipe de recherche au village.

5. Le changement climatique ne sera pas mentionné avant ou pendant l'activité. Au contraire, les conversations porteront sur les changements agricoles et les changements économiques afin d'éviter des réponses influencées.

6. La discussion devra être limitée à une durée de deux heures maximum.

7. Les participants ne recevront pas de compensation monétaire. Cependant, une simple collation leur sera offerte à l'issue de la discussion pour les remercier de leur participation.

8. Dans les villages de moins de 30 ménages, les villages voisins proches peuvent être inclus dans cet échantillon afin d'obtenir le nombre requis de participants. Le village le plus proche possible devrait être celui à inclure. Les discussions de groupe et les enquêtes auprès des ménages n'ont pas à être réalisées dans le même village, mais peuvent avoir lieu dans les villages voisins.

9. Chaque équipe du DFG aura 2 documents : ce guide et une fiche pour enregistrer les informations. L'animateur n'enregistre rien, mais peut prendre quelques notes. Les informations seront enregistrées par le rapporteur.

10. Après les deux discussions de groupe dans le village, l'animateur et le rapporteur va analyser les informations collectées dans leurs notes et va rédiger un rapport pour chaque FGD utilisant le plan du Rapport. Les deux membres de l'équipe doivent comparer leurs notes, discuter de l'information et de s'entendre sur le contenu du Rapport. Les deux Rapports par village sont extrêmement importants pour la compréhension de la spécificité de chaque village et les différences entre les expériences des hommes et des femmes. Par conséquent, les Rapports doivent être finis et entrées dans l'ordinateur avant que l'équipe quitte pour le prochain village. La qualité des Rapports sera évaluée par l'exhaustivité et la richesse des informations contenues. C'est une tâche importante pour les membres de l'équipe engagés dans les discussions de groupe et doit être traitée avec le plus haut niveau de professionnalisme et de dévouement.

Plan thématique du DFG :

1. CARACTERISTIQUES DES MOYENS DE SUBSISTANCE DU VILLAGE (20 min) : cet ensemble de thèmes sert à susciter des informations contextuelles sur les moyens de subsistance dans le village, sur une compréhension générale des technologies prédominantes, la gestion des ressources naturelles, la mobilité, la dépendance au marché et les vulnérabilités locales. Utilisez la matrice ci-dessous.

MATRICE 1 : POUR LE VILLAGE DANS SON ENSEMBLE, POSEZ DES QUESTIONS SUR CES CATÉGORIES DE CONNAISSANCES DANS UNE CONVERSATION INFORMELLE, SEMI-STRUCTURÉE :

Activités agricoles	Cultures principales	Activités saisonnières	Principales technologies	Commercialisation des produits
Activités pastorales	Principales espèces	Activités saisonnières	Principales technologies	Commercialisation des produits
Gestion des ressources naturelles	Utilisation des forêts (bois de chauffe, construction, ventes, etc.)	Ressources en eau (où, disponibilité saisonnière, marres, etc.)	Accès au foncier (types d'occupation des terres, utilisation des pâturages, héritage, etc.)	
Mobilité des villageois	Caractéristiques de l'exode (permanente, temporaire, où, professions)	Transhumance (qui s'en va, quand, où, pour combien de temps)	Transferts de fonds	Enfants à l'école (où, combien de temps, quelle sorte d'école)
Vulnérabilités/difficultés locales	Agriculture	Élevage	Eau	Accès aux revenus
Liens avec l'extérieur	Services gouvernementaux	Présence d'ONG	Liens religieux	Liens avec le secteur privé

2. TYPES DE CHANGEMENT DURANT CES 20 DERNIERES ANNEES (30 min) :
Souvenez-vous, il y a 20 ans, période de la dévaluation du Franc CFA À quoi ressemblait votre village à l'époque ? Décrivez les principaux changements dans la communauté (agricoles et non agricoles) depuis lors. [Enregistrez les changements mentionnés dans la Matrice 2. Attendez. Ensuite, posez les questions ci-dessous.]

MATRICE 2: POUR LE VILLAGE DANS SON ENSEMBLE, ENREGISTREZ LES TYPES DE CHANGEMENTS DANS LE TABLEAU CI-DESSOUS. UNE FOIS LES CHANGEMENTS DÉCRITES, DEMANDEZ LES CAUSES DE CES CHANGEMENTS.

Type de changement	Décrire les changements des 20 dernières années	Causes de changement
Population (# de Ménages, etc.)		
Profil global des moyens de subsistance (éleveurs, agro-pasteurs, agriculteurs)		
Les bâtiments, les magasins, types de maisons		
Mobilité (immigration, émigration)		
Revenus (types, proportions)		
Les pratiques agricoles, la taille des exploitations, les cultures, rendement agricole, variétés cultivées, etc.		
Pratiques d'élevage, composition du troupeau, nombre, etc.		
Qualité des pâturages, composition des espèces		

végétales		
Qualité des forêts		
Changes pluviométriques		

3. LES CHANGEMENTS SPECIFIQUES (30 min) : Toujours en revenant à 20 ans en arrière, et pour les cinq cultures les plus importantes, demandez quels changements sont survenus depuis lors dans les pratiques agricoles. Utilisez les Matrice 3 et 4 ci-dessous.

MATRICE 3: POUR LE VILLAGE DANS SON ENSEMBLE, DEMANDEZ LES CHANGEMENTS DANS LES MODES DE CULTURE DE CHAQUE CULTURE.

A. Cultures actuellement cultivées

#	Culture actuelle	Zone de production avant et actuelle (type de terre)	Quantité avant et actuelle	Raison/cause de ces changements de zone de production ou de quantité cultivée ? (Par exemple, l'épuisement des sols, manque de main-d'œuvre, maladie, modification des droits sur la terre, changement dans les prix du marché, changement de régime climatique? autre?)
1				
2				
3				
4				
5				

B. Cultures qui se sont pas plus cultivées

#	Pour les cultures qui ne sont plus cultivées	Pourquoi ne sont-elles plus cultivées?
1		
2		
3		
4		
5		

C. Cultures nouvelles que sont cultivées après les vingt ans

#	Pour les nouvelles cultures	Pourquoi sont-elles cultivées maintenant ?
1		
2		
3		
4		

4. **CHANGEMENTS DANS LA PRATIQUES AGRICOLES DES CULTURES (20 min)** : Pensez à toute la *campagne agricole*, y compris les décisions pour cultiver (de production), les intrants, les tâches sur le champ, les décisions de commercialisation, la répartition du travail, etc. Prenez les trois cultures le plus importantes cultive actuellement et décrivez la manière dont les systèmes de production et de commercialisation ont changé en 20 ans, en utilisant le tableau ci-dessous.

MATRICE 4: POUR LE VILLAGE DANS SON ENSEMBLE, DEMANDEZ LES CHANGEMENTS DANS LES PRATIQUES AGRICOLES POUR LES 3 CULTURES LES PLUS IMPORTANTES. UN ESPACE EST PREVU POUR CHACUN DES TROIS CHANGEMENTS PAR CULTURE

Culture	Changement	Raison du changement	Source d'idée
Culture 1 :	a.		
	b.		
	c.		
Culture 2 :	a.		
	b.		
	c.		
Culture 3 :	a.		
	b.		
	c.		

5. CHANGEMENTS SPÉCIFIQUES DANS LES PRATIQUES D'ÉLEVAGE (30 min) : Toujours en revenant à 20 ans en arrière, demandez quelles sont les changements qui sont enregistrés depuis lors dans les pratiques d'élevage du bétail. Utilisez Prompt Matrix 5 et 6 ci-dessous.

CHANGEMENTS DANS LA GESTION DES TROUPEAUX ET DES PATURAGES AU COURS DES 20 DERNIÈRES ANNÉES (MATRICES 5A ET 5B).

MATRICE 5A : AU COURS DES 20 DERNIÈRES ANNÉES POUR LE VILLAGE DANS SON ENSEMBLE, ENREGISTREZ LES CHANGEMENTS DANS LA COMPOSITION DES ESPÈCES, LA TAILLE DES TROUPEAUX, LES PÂTURAGES, LES PRATIQUES D'ÉLEVAGE, LA RÉPARTITION DU TRAVAIL, ETC. DANS LES TABLEAUX CI-DESSOUS.

Espèces d'animaux détenues actuellement	Changements sur les races	Changements sur la taille des troupeaux	Changements dans le LOCALE DE pâturage (saison pluvieuse)	Changements dans le LOCALE pâturage (saison sèche)	Raison des changements dans les races, taille des troupeaux ou DES LOCALES DE pâturages
1.					
2.					
3.					
4.					
5.					

MATRICE 5B: DESCRIPTIONS DES CHANGEMENTS DANS LA GESTION DU BÉTAIL PENDANT 20 ANS ET RAISONS POUR LES CHANGEMENTS.

Pratique de gestion	Avant	Maintenant	Raisons pour le changement	Source de changement
Routes (pistes) de transhumance				
Composition des espèces de pâturage				
Répartition du travail dans la gestion des troupeaux				
Utilisation de cannes, de résidus de cultures, coupe et transport de foin				
Achat de foin, tourteaux, etc.				
Achat d'aliments ou pierre à lécher pour le bétail				
Utilisation de vaccin /contrôle des parasites et des maladies				
Sources d'eau/puits				
Commercialisation d'animaux				
Autres pratiques de gestion				

6. ADOPTION DE L'ÉLEVAGE ET DE L'AGRICULTURE (15 min) : Toujours en revenant à 20 ans en arrière, les femmes et les hommes du village ont-ils commencé des travaux agricoles alors qu'ils n'étaient pas auparavant des agriculteurs ou ont-ils commencé l'élevage alors qu'ils n'étaient pas éleveurs du bétail auparavant ? Pourquoi ?

MATRICE 6: ENREGISTREZ LES RAISONS POUR LESQUELLES LES HOMMES ET LES FEMMES DANS CE VILLAGE ONT COMMENCÉ À FAIRE DE L'ÉLEVAGE OU DES TRAVAUX AGRICOLES

Raisons pour commencer à faire de l'élevage	Raisons pour commencer à faire de l'agriculture

7. CONTRAINTES GÉNÉRALES DE CHANGEMENT (20) : Généralement, quelles contraintes limitent la production agricole ou l'élevage et qu'est-ce qui est nécessaire pour améliorer ou augmenter l'agriculture/l'élevage ? Utilisez la Matrice 8.

MATRICE 8 : ENREGISTREZ LES CONTRAINTES QUI EMPÊCHENT LES FEMMES ET LES HOMMES DE CE VILLAGE DE DÉVELOPPER DAVANTAGE DE CULTURES OU D'ÉLEVER PLUS DE BÉTAIL ET CE QUI EST NÉCESSAIRE POUR AMÉLIORER OU AUGMENTER L'ÉLEVAGE OU L'AGRICULTURE.

Contrainte	Que faire ?

ANNEX E. SELECTION OF SURVEY VILLAGES

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ETAPE 2 : SÉLECTION DES VILLAGES À ENQUÊTER.....72

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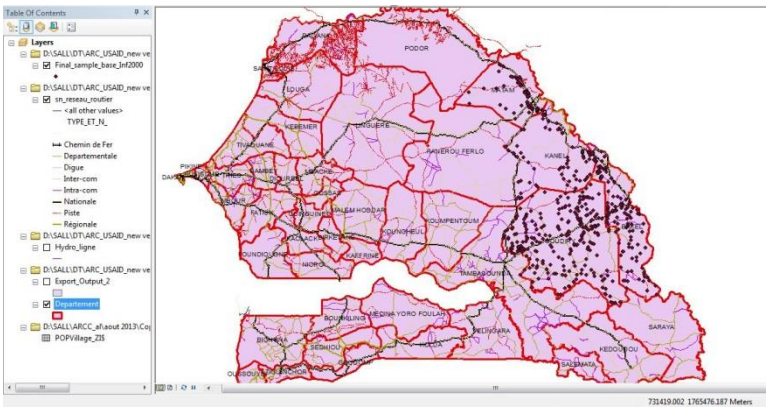
African and Latin American Resilience to Climate Change (ARCC)
USAID Contract Number AID-EPP-I-00-06-00008, AID-OAA-TO-11-00064

Title:	**Senegal Climate Change Vulnerability Assessment and Options Analysis**
Subcontractor:	Centre de Suivi Ecologique (CSE)
Duration:	**June 17, 2013 – October 31, 2013**
Supervisor:	Dr. David Miller, ARCC Technical Advisor for Africa

DELIVERABLE N°2 : DRAFT REPORT ON SELECTION OF SURVEY VILLAGES



INTRODUCTION

La prise en compte de la dimension spatiale est fondamentale dans la préparation des enquêtes qui visent l'intégration de l'analyse spatiale dans l'exploitation des résultats. Cela exige l'utilisation du GIS dès l'entame de tout processus de planification de l'étude. Cette note propose une procédure pour la détermination de la base géographique d'enquête.

L'enquête couvre deux zones: la zone nord qui couvre les départements administratifs de Matam et Kanel, et la zone sud qui épouse les limites administratives des départements de Bakel et Goudiry.

Pour s'assurer que les données issues de l'enquête socioéconomique pourraient être spatialisées de manière cohérente avec les données biophysiques (climat, pâturages, hydrologie), l'enquête devra être conduite sur une base géographique. En conséquence, deux niveaux d'échantillonnage seront à considérer :

- le premier consiste en la sélection de villages selon leur position géographique et
- le second niveau permettra à l'ISRA de sélectionner les ménages dans les villages choisis.

Les villages d'enquête ont été sélectionnés en fonction des critères suivants :

1. Ils sont localisés dans la zone du *Diéry* : au-delà delà route nationale vers le F*erlo*;
2. Leur population est inférieure à 2000 habitants ;
3. Ils sont répartis entre les deux zones et en fonction du poids démographique de chaque zone;
4. Les villages sélectionnés sont- distants d'au moins 10 km.

L'enquête étant prévue pour porter sur environ 400 ménages, le nombre de villages sélectionnés (quinze)a été ajusté en fonction de la taille de population pour un nombre moyen de trente ménages par village.

SÉLECTION DES VILLAGES À ENQUÊTER

Elle a été faite en utilisant l'outil d'échantillonnage « Sampling Design Tool » édité par la NOAA sur ArcGIS. Les localités situées dans la zone d'étude sont extraites de la base données du CSE avec leurs attributs (région, arrondissement, communautés rurales et villages, population, code administratif).

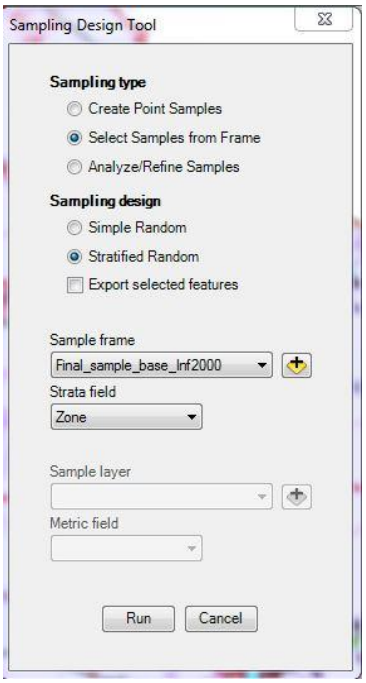
Etape 1 : Spatialisation des critères

A ce stade, le premier critère (villages de la zone du Diéry) a été retenu pour la zone nord. La couche du réseau routier (route nationale 2) a été combinée à celle des départements pour sélectionner les villages qui sont situés à l'intérieur. Ensuite les localités de moins de 2.000 habitants ont été extraites et enregistrées dans un fichier de base qui a servi comme données d'entrée à l'outil d'échantillonnage« Sampling Design Tool ». Il s'agit d'un outil qui permet d'obtenir des résultats fiables à un moindre coût dans un environnement SIG.

Etape 2 : Sélection des villages à enquêter

A l'aide de l'outil « Sampling Design tool », l'échantillonage des villages à enquêter a été fait selon la *méthode aléatoire stratifiée* en tenant compte de la taille de la population dans chaque zone. Ce procédé (quotas ou stratification) nécessite plus d'information sur les localités que les échantillonages systématique ou aléatoire élémentaire. En contrepartie, il fournit des échantillons plus fidèles.

Comme mentionné, il a été procédé à une partition de notre base de sondage en zones (nord et sud), chacune relativement homogène et en échantillonnant chaque zone (ou strate) séparément (fig 1). Un échantillon est alors prélevé dans chaque strate prise isolément, et on obtient les estimations pour chaque strate. Celles-ci ont été combinées pour donner l'estimation de l'ensemble des villages à enquêter.



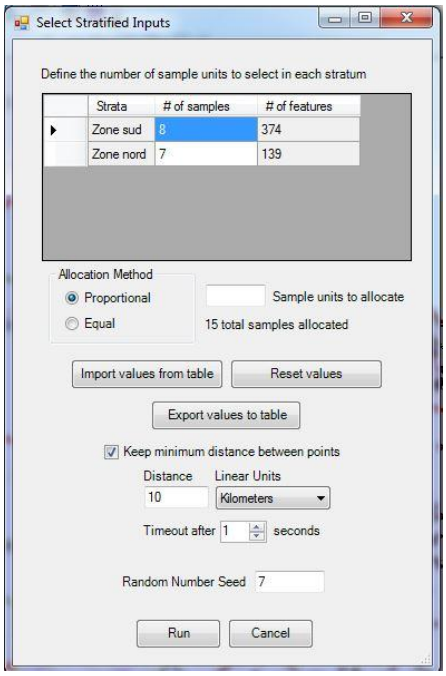
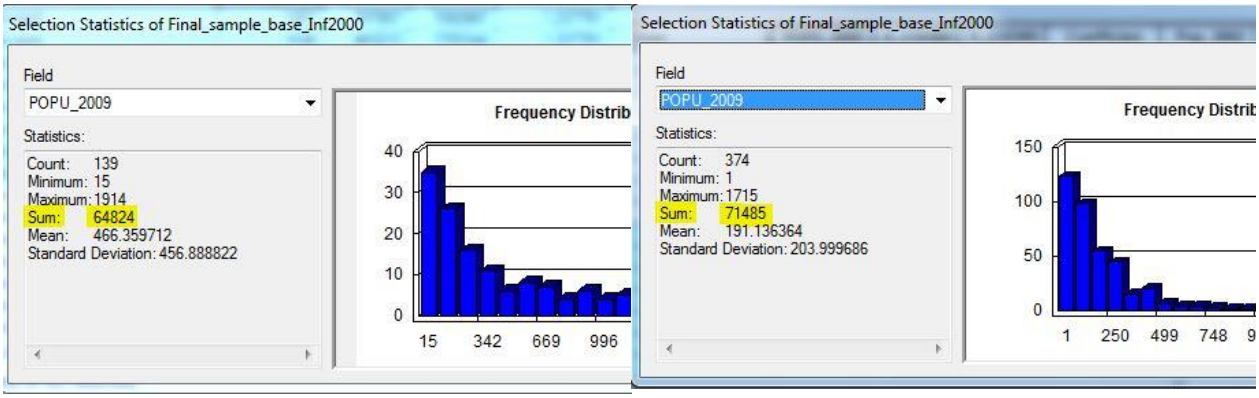


FIG. 1 - interface du "Sampling Design Tool" **FIG. 2**- procédure de stratification

La deuxième fenêtre (fig2) permet de définir les options de répartition des échantillons par strate, nombre identique pour chaque strate ou proportionnel au poids de chaque strate. La méthode proportionnelle est choisie ici pour tenir compte du poids démographique de chaque zone. La « population-mère » de la zone d'étude est de 136 309 habitants. Les zones nord (Matam et Kanel) et sud (Goudiry et Bakel) représentent respectivement 47% et 53% de la population (FIG 3). C'est ainsi que huit villages ont été sélectionnés dans la zone sud et 7 villages dans la zone nord.



Population de la zone nord : **64 824 habitants** Population de la zone sud : **71 485 habitants**

FIG. 3 - population totale de chaque zone (Source : CSE, ANSD)

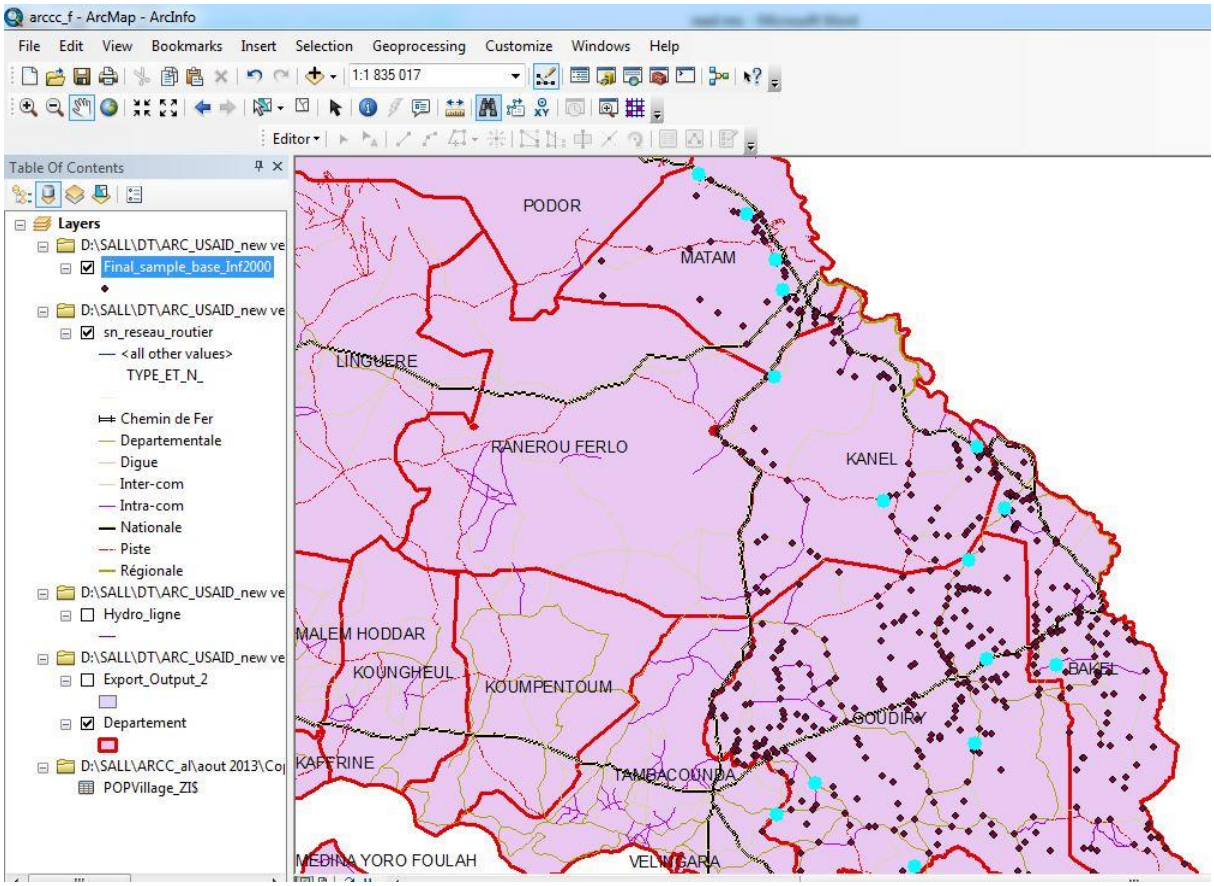


FIG. 4 - Villages à enquêter (en bleu); (Source :, CSE, ANSD)

Table

Final_sample_base_Inf2000

FID	Shape *	TOPONYMIE	NOMCR	NOMDEP	Zone	POPU_2009	X_COORD	Y_COORD	Coefficien
165	Point	Sinthiou Madina	Gabou	BAKEL	Zone sud	92	761874	1636620	1.02838
405	Point	Samba Kolo	Sinthiou Fissa	BAKEL	Zone sud	369	782787	1573651	1.02838
17	Point	Diyala	Dougue	GOUDIRY	Zone sud	20	750072	1541959	1.02838
22	Point	Katayel	Komoti	GOUDIRY	Zone sud	23	725573	1492701	1.02838
171	Point	Godioyel	Koar	GOUDIRY	Zone sud	93	669809	1513381	1.02838
302	Point	Boulel	Sinthiou Mamadou Bou	GOUDIRY	Zone sud	197	747373	1615570	1.02838
307	Point	Mbakanabe	Sinthiou Mamadou Bou	GOUDIRY	Zone sud	206	754511	1575913	1.02838
449	Point	Koar	Koar	GOUDIRY	Zone sud	540	685313	1525994	1.02838
43	Point	Ouro Cebo	Ouro Sidy	KANEL	Zone nord	32	668554	1689356	1.237761
50	Point	Ouro Silamaka	Bokiladji	KANEL	Zone nord	37	750685	1661369	1.237761
282	Point	Boulone Samba Djadji	Aoure	KANEL	Zone nord	178	712983	1639434	1.237761
297	Point	Hontorbe	Nabadji Civol	MATAM	Zone nord	191	669284	1736582	1.237761
445	Point	Asnde Balla	Orefonde	MATAM	Zone nord	521	638061	1770972	1.237761
452	Point	Kirire I	Bokidiawe	MATAM	Zone nord	559	657584	1755045	1.237761
492	Point	Thiancone Hiraye	Ogo	MATAM	Zone nord	1074	672373	1724397	1.237761

1 (15 out of 513 Selected)

Final_sample_base_Inf2000

FIG. 5-: villages à enquêter

TABLEAU 1 : VILLAGES SÉLECTIONNÉS

Num	Villages	Zone	Pop 2002[x]	Pop 2009[xx]
1	Sinthiou Madina	Zone sud	89	92
2	Samba Kolo	Zone sud	359	369
3	Diyala	Zone sud	19	20
4	Katayel	Zone sud	22	23
5	Godioyel	Zone sud	90	93
6	Boulel	Zone sud	192	197
7	Mbakanabe	Zone sud	200	206
8	Koar	Zone sud	525	540
9	Ouro Cebo	Zone nord	26	32
10	Ouro Silamaka	Zone nord	30	37
11	Boulone Samba Djadji	Zone nord	144	178
12	Hontorbe	Zone nord	154	191
13	Ansde Balla	Zone nord	421	521
14	Kirire I	Zone nord	452	559
15	Thiancone Hiraye	Zone nord	868	1074

(Source : ANSD)

[x] Recensement Général de la population et de l'Habitat de 2002

[xx] Estimation de la population en 2009

CONCLUSION

Les quinze villages ont été sélectionnés de manière rigoureuse sur la base d'un échantillonnage aléatoire stratifié en se basant sur une approche cartographique utilisant un outil élaboré à cet effet. Cette approche facilitera par la suite la spatialisation et la modélisation des degrés de vulnérabilité des communautés et des écosystèmes.

ANNEXE E1: SÉLECTION DE VILLAGES SUPPLÉMENTAIRES

Des villages supplémentaires, au nombre de sept (7), ont été tirés, afin de palier à la non disponibilité ou l'inaccessibilité éventuelles des villages du premier tirage. L'extraction de l'échantillon supplémentaire s'est pliée aux mêmes règles et précautions observées lors du tirage des 15 villages. Sauf que cette fois-ci, les 15 villages ont été isolés au préalable, afin d'éviter qu'ils ressortent une deuxième fois.

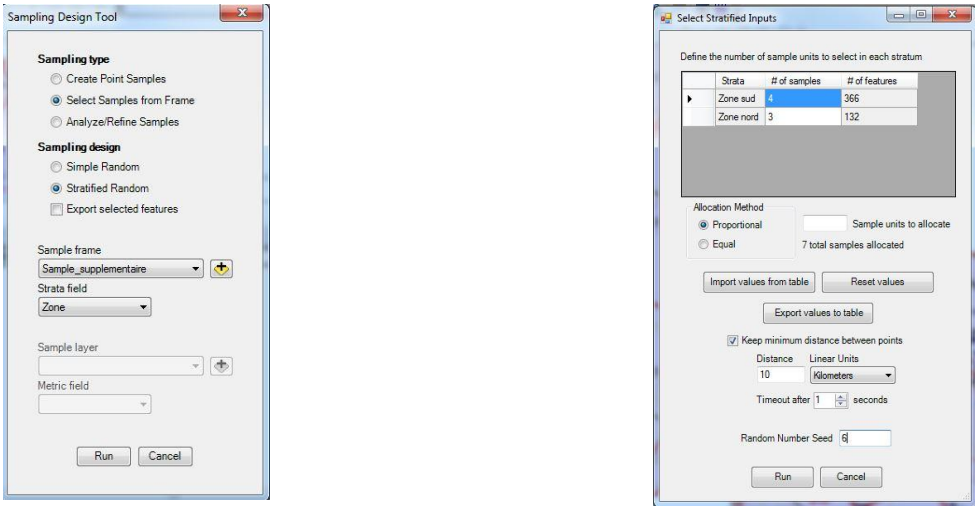


FIG. A-1 Procédure

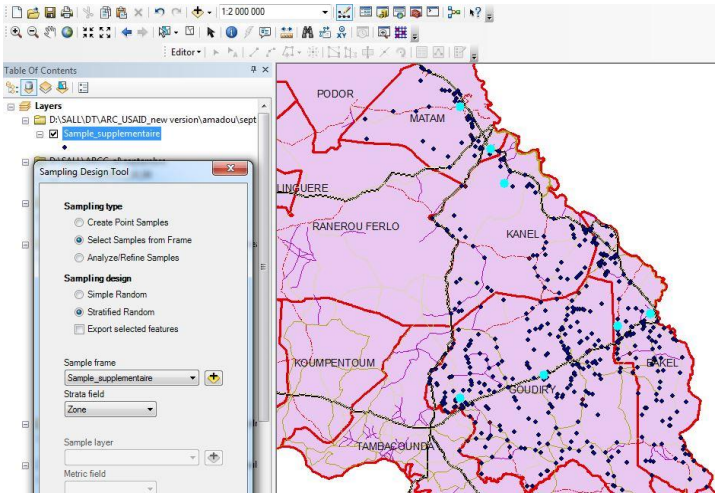


FIG. A-2 localisation des villages sélectionnés

Table

Sample_supplementaire

TOPONYMIE	NOMCR	NOMDEP	Zone	Pop_2002	POPU_2009	X_COORD	Y_COORD
Gambi	Koulor	GOUDIRY	Zone sud	153	157	664899	1543238
Boynguel Bamba	Boynguel Bamba	GOUDIRY	Zone sud	297	305	723095	1558867
Arigabo	Bele	BAKEL	Zone sud	338	348	774266	1592939
Andy Yari	Ndendory	KANEL	Zone nord	310	384	695428	1691302
Sinthiou Diohe	Bele	BAKEL	Zone sud	618	636	797206	1601262
Sedo Abass	Nabadji Civol	MATAM	Zone nord	844	1045	664706	1744192
Sinthiou Garba Ganky	Ogo	MATAM	Zone nord	1252	1550	685722	1715114

0 (7 out of 498 Selected)

Sample_supplementaire

FIG. A-3 villages supplémentaires

ANNEX F. INITIAL REPORT VISIT

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BUREAU D'ANALYSES MACRO-ÉCONOMIQUES

ETUDE ARCC

EVALUATION DE LA VULNÉRABILITÉ FACE AU CHANGEMENT CLIMATIQUE ET ANALYSE DES OPTIONS

RAPPORT DE MISSION SUR LA PRISE DE CONTACT ET LA PROSPECTION DES VILLAGES RETENUS POUR L'ÉTUDE

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Cheikh Mbaye (chauffeur ISRA-LNRPV)

Moyens de transport : Véhicule 4483 TTC1

Date de départ : 21 Octobre 2013

Date de retour : 28 Octobre 2013

Lieu : départements de Matam, Kanel, Bakel, Kidira et Goudiry

1.0 MOTIFS

- Prise de contact avec les chefs des villages retenus pour l'étude
- Informations préliminaires

2.0 DÉROULEMENT DE LA MISSION

Dans le cadre de l'évaluation de la vulnérabilité des ménages face aux changements climatiques ; une mission de prospection s'est déroulée, du 21 au 28 octobre 2013, dans 15 villages des départements de Matam, Kanel, Bakel, Kidira et Goudiry. L'objectif de cette prospection était de prendre contact avec les chefs de villages et d'avoir des informations préliminaires sur les activités économiques villages ciblés.

2.1. Prise de contact avec les chefs de villages

La mission s'est rendue dans tous les villages retenus à l'exception de Katayel et Diyala qui étaient inaccessibles à causes des eaux. Ces villages ont été remplacés par Gambi et Boynguel Bamba. Certains villages qui faisaient moins de trente (30) ménages (Ouro Cebbo, Oura Silamaka, Boulone Samba Djadji, Godioyel Bocar Yoro, Boulel et Sinthiou Madina) ont été associés à d'autres villages (Tableau 1). Les chefs de village ont bien accueilli la mission et sont disposés à informer les populations et à faciliter les enquêtes.

Après chaque discussion avec le chef de village, ses coordonnées du chef ainsi que celles d'une autre personne ressource du village ont été prises pour les informer du calendrier des enquêtes (Tableau 2).

TABLEAU 1 : VILLAGES VISITÉES

Numéros	Noms Villages	Villages associés	CR	Arrondissements	Départements
1	Hontorbe		Nabadji Civol	Ogo	MATAM
2	Asnde Balla		Orefonde	Agnam Civol	MATAM
3	Kirire I		Bokidiawe	Ogo	MATAM
4	Thiancone Hiraye		Ogo	Ogo	MATAM
5	Ouro Cebo	Thiéwelé	Ouro Sidy		KANEL
6	Ouro Silamaka	Ouro Mbollèle	Bokiladji	Orkadiéré	KANEL
7	Boulone Samba Djadji	Lordougo	Aoure	Orkadiéré	KANEL
8	Boynguel Bamba		Boynguel Bamba	Boynguel Bamba	GOUDIRY
9	Gambi		Koar	Bala	GOUDIRY
10	Godioyel Bocar Yoro	Noumouyel	Koar	Bala	GOUDIRY
11	Boulel	Toulé Kédé	Sinthiou Mamadou Bou	Koulor	GOUDIRY
12	Mbakanabe		Sinthiou Mamadou Bou	Koulor	GOUDIRY
13	Koar		Koar	Bala	GOUDIRY
14	Sinthiou Madina ou Gourel Bobou	Gourel Dioloubé	Gabou	Moudéry	BAKEL
15	Samba Kolo		Sinthiou Fissa	Belle	BAKEL

TABLEAU 2 : CONTACTS DES CHEFS DE VILLAGES ET AUTRES PERSONNES RESSOURCES

Num	Noms Villages	Chefs de villages	Numéro téléphone CV	Autres personnes ressources et Num tél
1	Hontorbe	Abdoulaye Samba Ba	706520323	Yoro Kéréro Ba : 778696885
2	Asnde Balla	Seydou Youbi Ba	775136803	Bolo Ba : 771381240
3	Kirire I	Abdoul Moussa Dia	772058138	Alassane Barry
4	Thiancone Hiraye	Ismaëla Ba	772196349	Thierno Aly Ba : 775944425
5	Ouro Cebo	Goulal Ba	773348036	Alousseyni Ba 770889234
Village associé à Ouro Cebo	Thiéwelé	Mamadou Harona Ba	775706004	Harona K Ba 777381202
6	Ouro Silamaka	Samba Traoré	771538510	
Village associé à Ouro Silamako	Ouro Mbollèle	Mberkeldy Nguett	770185719	Sara Nguett 776161012
7	Boulone Samba Djadji	Hamady Déh	339828716	Samba Déh 775912283
Village associé à Boulone Samba Djadji	Lordougo	Samba Diallo	339667336	
8	Boynguel Bamba	Mamadou Sow	778072289	Omar Ndiaye 709547599 Mamadou Ndiaye

9	Gambi	Djiby Ba	779383118	Souleymane Ba 777909665
10	Godioyel Bocar Yoro	Samba Diallo	339816057	Saliou Dioum 777089538
Village associé à Godioyel Bocar Yoro	Noumouyel	Mamadou Diallo	774024123	Abdoul Diallo 776137898
11	Boulel	Baye Mangane	339836388	Moussa Mangane 776647864
Village associé à Boulel	Toulé Kédé	Demba Sory Ndom	339839453	Hamady Ndom 339804010
12	Mbakanabe	Mamadou Koundio	776114941	Amadou Dieng 779171827
13	Koar	Basamba Sokhouna	777490520	Diabel Sow 770121203
14	Sinthiou Madina	Hamidou Diallo	707817944	Baïla Diallo 706552189 339842523
Village Associé à Sinthiou Madina	Gourel Dioloubé	Fally Mangane	708247667	Mamadou Cissé 704083380
15	Samba Kolo	Ousmane Sy	773042818	Sada Ba 773875955

2.2. Informations préliminaires

2.2.1. Activités économiques (Tableau 3)

Sur l'ensemble des zones considérées, l'agriculture et l'élevage constituent les principales activités économiques. Le commerce constitue une activité secondaire au niveau de ces départements. Ainsi, la plupart des villages sont éloignés des chefs lieu de communautés rurales où se situent l'essentiel des marchés d'approvisionnement. Cependant, le principal problème est l'absence de routes praticables qui limite les déplacements des populations. On note également la présence de quelques pêcheurs qui sont localisés dans le département de Matam.

Agriculture (Tableau 3)

L'activité agricole reste principalement dominée par la culture du Mil, du Sorgho, du Mais et de l'Arachide sur l'ensemble des zones. En dehors de ces cultures, on note quelques spécificités selon les départements. En effet, si la culture du Niébé et de la courge sont principalement pratiquées dans les départements de Matam et de Kanel, dans les départements de Bakel et de Goudiry, ce sont les autres cultures maraîchères qui viennent en seconde position après les cultures principales citées ci-dessus.

Elevage (Tableau 3)

Le bétail est principalement constitué de Bovins, Ovins, Caprins, Asins, Caprins et de la volaille sur l'ensemble des zones considérées. La commercialisation du lait reste cependant très faible. Cela est principalement dû à l'absence de routes praticables pour acheminer les produits sur le marché, notamment pendant l'hivernage.

2.2.2. Principales contraintes liées aux activités agropastorales (Encadré 1)

La rareté et l'irrégularité des pluies constituent les principales contraintes identifiées par les populations. Ainsi, la sécheresse apparait comme étant le phénomène ayant le plus négativement impacté sur les activités agropastorales au niveau de ces zones, notamment à Matam et à Kanel où elle est plus accentuée. Cette sécheresse se manifeste par le fait que le fourrage, qui sert de nourriture au bétail, n'arrive pas à maturité ou est souvent de mauvaise qualité. A cela s'ajoute la déforestation et la fréquence des feux de brousse qui détruisent le couvert végétal. Ainsi, le manque de pâturage pousse les populations à la transhumance vers le Mali, la Mauritanie ou d'autres localités jugées plus clémentes, à partir du mois de janvier. On note aussi l'absence ou la non opérationnalité de forages dans la plupart des villages.

La présence de certains ravageurs tels que les oiseaux, les insectes et les termites qui détruisent les cultures, les maladies du bétail , la divagation des animaux limitent les activités agro-pastorales. On peut aussi mentionner la vétusté du matériel agricole, l'inaccessibilité des semences, fertilisants et autres intrants.

ENCADRÉ 1 : CONTRAINTES SELON DES DÉPARTEMENTS

Département de Matam

- Rareté des pluies et ses conséquences sur le cheptel et l'activité agricole
- Irrégularité des pluies
- Maladie de la Volaille
- Oiseaux et insectes ravageurs
- Inaccessibilité des semences de mils et de sorgho et de l'engrais dans une moindre mesure

Département de Kanel

- Rareté des pluies ses conséquences sur le cheptel et l'activité agricole
- Divagation des animaux
- Termites
- Quelques forages non opérationnels
- Vétusté des équipements agricoles

Département de Goudiry

- Rareté des pluies ses conséquences sur le cheptel et l'activité agricole
- Vétusté du matériel Agricole
- Inexistence de forages dans certaines zones (Boulel)
- Manque d'intrants de qualité (semences, engrais et produits phytosanitaire)
- Divagation des animaux

Département de Bakel

- Oiseaux ravageurs
- Termites
- Rareté des pluies
- Forages non opérationnels à Sinthiou Madina

2.3. Difficultés rencontrées

Les pannes répétées du véhicule, l'éloignement de certains villages et l'état des pistes ont été les principales contraintes de cette mission de prospection.

2.4. Proposition d'un programme d'enquêtes

Sur la base de la prospection des villages ciblés et des difficultés rencontrées, un programme d'enquête (Tableau 4) et quelques recommandations ont été proposés par les missionnaires. A cet effet, la mission propose de :

- Valider le programme d'enquêtes
- Elaborer un programme de formation sur 2 jours
- Faire le test du questionnaire en 1 ou 2 jours
- Entamer les enquêtes 1 ou 2 jours après le test du questionnaire
- Appeler tous les chefs de village pour les informer de la date des enquêtes
- Contacter des guides pour certains villages enclavés (Boulone Samba Djadji, Ouro Cebbo, Ouro Silama, Boulel, Sinthiou Madina, Samba Kolo, Koar et Godioyel)

Contacts Guide Abda: 774793478 (Ouro silamaka, Bolone Samba Djadji, Ouro Silamaka)

TABLEAU 3 : SPÉCULATIONS, COMPOSITION CHEPTEL, MARCHÉS ET PRINCIPALES ACTIVITÉS

Num	Noms Villages	Spéculations	Composition du cheptel	Marchés hebdomadaires	Principales Activités	Nombre ménages
1	Thiancone Hiraye	Mil, sorgho, niébé, arachide	Bovins, ovins, caprins	Ourosogui (tous les jours)	Agriculture et élevage	
2	Hontorbe	Mil, sorgho, Niébé, Arachide	Bovins, ovins, caprins, équins, asins, volaille	Chef lieu CR Nabadji Siwol	Agriculture et élevage	60 Carrés 34 Cons
3	Kirire I	Mil, Pastèque, Niébé, Sorgho, Bissap	Bovins, ovins, caprins, équins, asins, volaille	Chef lieu CR Nabadji Siwol	Agriculture, Elevage et Commerce du lait	91 Carrés
4	Asnde Balla	Mil, Mais, Sorgho et Niébé	Bovins, ovins, caprins, équins, asins, volaille	Aganme Thiodèye (Mardi)	Agriculture, Elevage, Pêche et Commerce	73 Carrés
5	Ouro Cebo	Mil, Mais, Sorgho et Niébé, Courge et	Bovins, ovins, caprins, équins, asins et volaille	Ourosogui (tous les jours)	Agriculture, Elevage et Commerce	11
6	Ouro Silamaka	Mil, Mais, Sorgho et Courge	Bovins, ovins, caprins, équins, asins et volaille	Louma Bonji	Agriculture et Elevage	
7	Boulone Samba	Mil et Maïs	Bovins, ovins, caprins, équins et asins	Louma Doundé	Agriculture et Elevage	Environs 14
8	Boynguel Bamba	Mil, Mais, Sorgho arachide, Cultures	Bovins, ovins, caprins, équins, asins et volaille	Louma de Bala (Samedi)	Agriculture et Elevage	75
9	Gambi	Mil, Arachide, Riz, Sorgho et Maïs	Bovins, ovins, caprins, équins, asins et volaille	Louma de Kothiatri	Agriculture et Elevage	Environ 36
10	Godioyel Bocar	Mil, Mais, Sorgho	Bovins, ovins, caprins, équins, asins et volaille	Louma de Kothiatri	Agriculture, Elevage	16
11	Boulel	Mil, Mais, Sorgho arachide, Niébé et urge	Bovins, ovins, caprins, équins, asins et volaille	Louma Gabou	Agriculture, Elevage et Commerce	
12	Mbakanabe	Mil, Mais, Sorgho arachide, Cultures	Bovins, ovins, caprins, équins, asins et volaille	Louma de Bala (Samedi)	Agriculture et Elevage	45
13	Koar	Arachide, Mais, Sorgho, Mil, Igname	Bovins, ovins, caprins, équins, asins et volaille		Agriculture, Elevage et Commerce	70
14	Sinthiou Madina	Mil, Mais, Sorgho arachide, Gombo et	Bovins, ovins, caprins, équins, asins et volaille	Louma Gabou Louma Bondji	Agriculture, Elevage et Commerce	17
15	Samba Kolo	Mil, Maïs, Sorgho arachide et Gombo	Bovins, ovins, caprins, équins, asins et volaille	Goudiry et Kidira	Agriculture, Elevage et Commerce	37

TABLEAU 4 : PROPOSITION D'UN PROGRAMME DES ENQUÊTES SOCIO-ÉCONOMIQUES

Num	Noms Villages	Hôtels, auberges ou Campements	Dates Prévues pour les enquêtes	Equipes
1	Thiancone Hiraye	Ourossogui	Du 18 au 19 Novembre	Equipe Nord
2	Hontorbe	Ourossogui	Du 20 au 21 Novembre	Equipe Nord
3	Kirire I	Ourossogui ou Bokidiawé	Du 22au 23Novembre	Equipe Nord
4	Asnde Balla	Ourossogui ou Bokidiawé	Du 24 au 25 Novembre	Equipe Nord
5	Ouro Cebo	Ourossogui	Du 26 au 27	Equipe Nord
	Trajet Ourosogui Bakel et Repos		**28 Novembre**	**Equipe Nord**
6	Ouro Silamaka	Bakel	Du 29 au 30 Novembre	Equipe Nord
7	Boulone Samba Djadji	Bakel	Du1er au 2 Décembre	Equipe Nord
8	Gambi	Tambacounda	Du 18 au 19 Novembre	Equipe Sud
9	Boynguel Bamba	Tambacounda	Du 24 au 25 Novembre	Equipe Sud
10	Godioyel	Tambacounda	Du 22au 23Novembre	Equipe Sud
12	Mbakanabe	Tambacounda	Du 26 au 27 Novembre	Equipe Sud
13	Koar	Tambacounda	Du 20 au 21 Novembre	Equipe Sud
	Trajet Tambacounda Bakel		**28 Novembre**	**Equipe Sud**
11	Boulel	Bakel	Du 29 au 30 Novembre	Equipe Sud
14	Sinthiou Madina	Bakel	Du1er au 2 Décembre	Equipe Sud
15	Samba Kolo	Bakel	Du 3 au 4 Décembre	Equipe Sud ou Equipe Nord

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES G – H

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ARCC

African and Latin American Resilience to Climate Change Project

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ANNEX G. LOCAL-LEVEL INSTITUTIONAL RESPONSES TO CLIMATE VARIABILITY AND EXTREMES IN SENEGAL

This annex was prepared by Sara-Katherine Coxon, Ayesha Dinshaw, Heather McGray, and Abigail Ofstedahl of the World Resources Institute through a subcontract to Tetra Tech ARD.

EXECUTIVE SUMMARY

This annex provides an overview of how local institutions in Senegal may facilitate adaptation to climate change. It draws upon a review of relevant literature and key informant interviews conducted with representatives of four types of local institutions: local government (Rural Communities); official technical assistance agencies; international development projects; and local markets.

The authors find several indications that local institutional adaptive capacity is weak. While key informants in all institution categories showed an awareness of climate shocks, they had very limited work underway to adapt proactively to these threats, and very little awareness of national-level efforts to collect and disseminate information about climate change (e.g., through the National Adaptation Programme of Action). Moreover, the study found that a lack of human, financial, and material capacity limits action on adaptation. Technical service providers and development project informants indicated a greater, though still limited, level of resources available to potentially support adaptation action.

The paper suggests four specific opportunities for improving local institutional capacity to contend with climate change. First, the role of Community Assistants could be made more permanent to increase job satisfaction, and expanded to provide technical support on adaptation activities. Second, civic and public institutions are currently partnering on development projects and potentially could cultivate partnerships that would link their complementary skill sets to enable local-level adaptation. Third, the Local Development Plans, which are the primary guiding document for local development, could incorporate guidance on adapting to climate change. Last, systematic efforts to harvest lessons from ongoing development projects and programs could identify ways to efficiently address climate change in the course of similar future work.

This annex provides a framework and guide for strengthening institutional readiness for contending with climate change. This framework is introduced at the beginning of the paper, and the four specific, identified opportunities are mapped onto this framework toward the end of the paper. The paper closes with recommendations for three areas of future research: why local-level public or civic institutions were not mentioned by key informant interviewees as sources for future support on climate change; case studies on public and civic collaboration that have enabled adaptation; and policy analysis that would identify options for including climate change in the Local Development Plans.

1.0 OVERVIEW

Institutions are "at the heart" of society's ability to respond to climate change because of the vitally important role they play in enabling and mediating adaptive capacity. This annex considers the roles and responses of local institutions in Senegal that contend, or could contend, with climate change. It focuses on Eastern Senegal and on institutions related to agriculture and livestock herding, which are most prevalent in communities in this region.

The paper begins with a brief introduction about how and why institutions matter for adaptation to climate change in Section 2. This introduction is followed by a brief summary of the research methods used for this annex in Section 3. Section 4 provides institutional background on Senegal. Section 5 provides a discussion of three local institution types that are identified as important for adaptation: public, civic, and market institutions. Section 6 presents overarching findings and discusses specific findings from the key informant interviews undertaken for the African and Latin American Resilience to Climate Change (ARCC) Vulnerability Assessment. In Section 7, the paper highlights recommendations for building institutional capacity for adaptation at the local level in Senegal. The first four Annexes provide supporting information, and Annex G-5 includes a list of acronyms.

2.0 INSTITUTIONS MATTER FOR ADAPTATION TO CLIMATE CHANGE

Institutions are important because they shape social behavior and outcomes. "[A]daptation practices depend for their success on specific institutional arrangements -- adaptation never occurs in an institutional vacuum" (World Bank, n.d.). Broadly speaking, local institutions shape how communities will experience climate change in three ways (World Bank, n.d.; Agarwal et al., 2008):

- by influencing the ways in which communities are impacted;
- by shaping the ways in which they can respond; and
- by mediating external interventions.

Institutions may be defined according to their structure or status (for example, private or nongovernmental); or process or function (for example, legal or participatory); and they may be formal or informal (WRI, 2011). In order to understand the impacts institutions have, it is important to examine their internal processes; external relationships; and links with individuals, households, and social groups (Agarwal, 2008).

Several dimensions of institutions are important for adaptation. These include: how institutions address or reinforce power imbalances; whether they are participatory and inclusive in their decision making (Brown, 2011); and whether they can be and are held accountable (Agarwal, 2008). These particular obligations are vital: "Given that entitlements to key resources needed to adapt can be differentiated along age, ethnicity, class, religion and gender (to name but a few), an institutional environment that allows equitable opportunities to all groups, particularly the marginal, and most vulnerable to the impacts of climate change is essential to building the capacity to adapt" (ACCRA, n.d.).

Simply having access to institutions therefore is also critical for enabling adaptation. A study conducted by Agarwal et al. (2011) shows a statistically significant relationship between greater institutional access and use of adaptation strategies. "Greater institutional access facilitates both greater use of and a greater diversity of adaptation strategies employed. Although there is a strong association between institutional access and the use of different adaptation strategies, the data do not provide sufficient detail on the extent to which the adaptation strategies used by households are effective" (Agarwal et al., 2011). Annex G-3 provides graphical representation of access to institutions and adaptation strategies undertaken in Senegal and other West African countries.

Special attention must be paid to the relationships between local institutions and "extra-local" actors involved in adaptation, such as development agencies. Typically, strengthening local institutions and working through them will be more effective in enabling adaptation than introducing new strategies designed by extra-local institutions without input from the community (Howard, 2012). However, some extra-local actors have bypassed local institutions. While this situation can be detrimental to the success of the intervention, it may be appropriate when an institution is entrenched in exclusionary social norms that prevent the involvement of marginalized communities. Development agencies may be enthusiastic to build the capacity of local institutions, but without a clear understanding of the relevance and role of these institutions and their coordination with other institutions, as well as true accessibility of the institution by the community, such efforts may be counterproductive (Howard, 2012).

Agarwal (2008) offers a useful typology of how institutions can enable adaptation to climate change. They can improve one or more of these strategies of adaptation:

- Mobility: perhaps the most common and seemingly natural response to climate change. This strategy pools risk across space.
- Storage: pools and reduces risk across time. Especially when infrastructure exists and there is coordination among a community, storage has immense potential to help communities in times of food and water losses due to climate change.
- Diversification: pools risks across assets and resources. Highly varied in form, this strategy can occur in relation to productive and non-productive assets, consumption strategies, and employment opportunities. It is reliable to the extent that activities and assets are subject to uncorrelated risks.
- Communal pooling: involves joint ownership of assets and resources, income, and wealth. It can also exist in the form of mobilizing resources already jointly held by the community. Its hallmark is joint action by members of the community.
- Market exchange: perhaps the most versatile of adaptation responses. Markets are a characteristic of almost all human groups; however, to be an effective adaptation response, markets require institutions that enable equity for the poor.

As the basis for assessing how well an institution can help enable adaptation to climate change, this annex focuses on three characteristics of institutions:

- whether the institution can manage information and knowledge to assess and prioritize climate risks;
- whether the institution is forward thinking to be flexible and innovative; and
- whether the institution is truly participatory to be responsive to the community within which it exists.

These characteristics have been distilled from other frameworks and studies that identify characteristics that are important for institutions that contend with climate change (see Annex G-4). These three characteristics are proposed here as the basis for assessing institutional capacity for contending with climate change. These characteristics stand out among others because they indicate an institution's *readiness* to enable adaptation. This readiness implies a sustained proactive effort that positions an institution to contribute to adaptation efforts over the long term, not simply a reactive effort in the face of a natural disaster. In addition to enabling institutional readiness for contending with climate change, these characteristics imply that institutions engage in a dynamic, continuous learning process that helps them avoid maladaptation.

Possessing these three characteristics requires a large amount of capacity, especially human capacity, and coordination. It would be challenging for an institution to attain these characteristics even in a developed country context. These characteristics could not be directly applied in this annex to gauge Senegal's current institutional capacity to contend with climate change at the local level. However, these characteristics were helpful in identifying indicators used to analyze key informant interviews (Table 2 and Table 3). These characteristics are expanded upon in Section 7 as a guide for future capacity development efforts that can enable better responsiveness to climate change at the local level in Senegal.

3.0 RESEARCH METHODS

For this annex, the authors conducted a literature review on the government structure of Senegal, the role of institutions in enabling local-level adaptation, and the specific institutions that play a significant role in adaptation at the local level in Senegal. The literature provided background information and recommendations that have been complemented by key informant interviews.

The African and Latin American Resilience to Climate Change (ARCC) Vulnerability Assessment included 40 key informant interviews conducted in Senegal. Annex G-1 contains the full list of interviewees, and Annex G-2 contains the interview questionnaires. The interviews were conducted by Mamadou Bobo Barry and Pape Bilal Diakhaté, economists in the office of macro-economic analysis in Senegal's Institute for Agricultural Research (ISRA). The interviews were conducted during a 25-day period, from November 12, 2013 to December 6, 2013. Four sets of stakeholders were interviewed:

- Presidents and/or Community Assistants of Rural Communities (see Box 2), which are local-level public institutions governed by Rural Councils;
- Technical Service providers, who report to ministries and work at the regional and department levels to implement and monitor development activities (Technical Service providers related to agriculture and livestock were selected for this study);
- Project Managers that represent domestic and international nongovernmental organizations (NGOs) as well as state agencies that implement development projects and programs; and
- Traders ranging from small-scale produce and livestock sellers to professional grain and livestock traders.

TABLE 1: KEY INFORMANT INTERVIEWS CONDUCTED

Category of interview	Number of interviews in the North	Number of interviews in the South	Total number of interviews
Rural Communities	7	7	14
Technical Services	5	3	8
Project Managers	3	4	7
Traders	6	5	11
Total interviews	**21**	**19**	**40**

The interviews were conducted in four departments in Eastern Senegal: Matam and Kanel in the North, and Bakel and Goudiry in the South. The map in Figure 1 shows the location of the four departments. This site choice was made after ARCC and the U.S. Agency for International Development (USAID)/Washington conducted a scoping study that revealed that much of the research and project activity invested in climate change focused on the country's coasts, rivers, deltas, and fisheries. Fewer studies had focused on the interior of the country. The study zone was selected because populations there face high levels of food insecurity, and because it is likely a target area for future USAID funding. In addition, much of the study zone falls into the Sahel, which makes findings applicable outside of Senegal.

The northern departments of Matam and Kanel contain arid pastoral zones, while the southern departments of Bakel and Goudiry contain more humid crop agriculture. Departments were chosen

across the North and the South to assess the spectrum of livelihoods in which people engage, and the factors that make households vulnerable. The hypothesis of the ARCC Vulnerability Assessment, of which this report is a part, is that households with livelihoods that include livestock are less vulnerable to climate change than those that do not include livestock and primarily depend on agriculture. A comparison of findings from the northern departments with those from the southern departments helps test this hypothesis.

FIGURE 1: MAP OF THE FOUR STUDY DEPARTMENTS

To analyze the key informant interview responses, the authors utilized indicators for each of the characteristics of institutions that can enable adaptation, as described in Table 2 below. The full analysis of key informant findings is presented in Table 3 on page 20.

TABLE 2: RESEARCH FRAMEWORK FOR THE KEY INFORMANT INTERVIEWS

Institutional Characteristics That Convey Adaptive Capacity	Indicators for Each Characteristic (Per Informant Category)			
	Rural Communities	*Technical Service Providers*	*Development Actors*	*Traders*
Manage information and knowledge to prioritize climate change risks	Awareness of climate threats			
Be forward-thinking in order to be flexible and innovative	Capacity		Work that could contribute to adaptation	Institutional needs identified
Be truly participatory to be responsive to community needs	Current work on climate impacts			Changes in behavior due to climate impacts

4.0 INSTITUTIONAL BACKGROUND OF SENEGAL

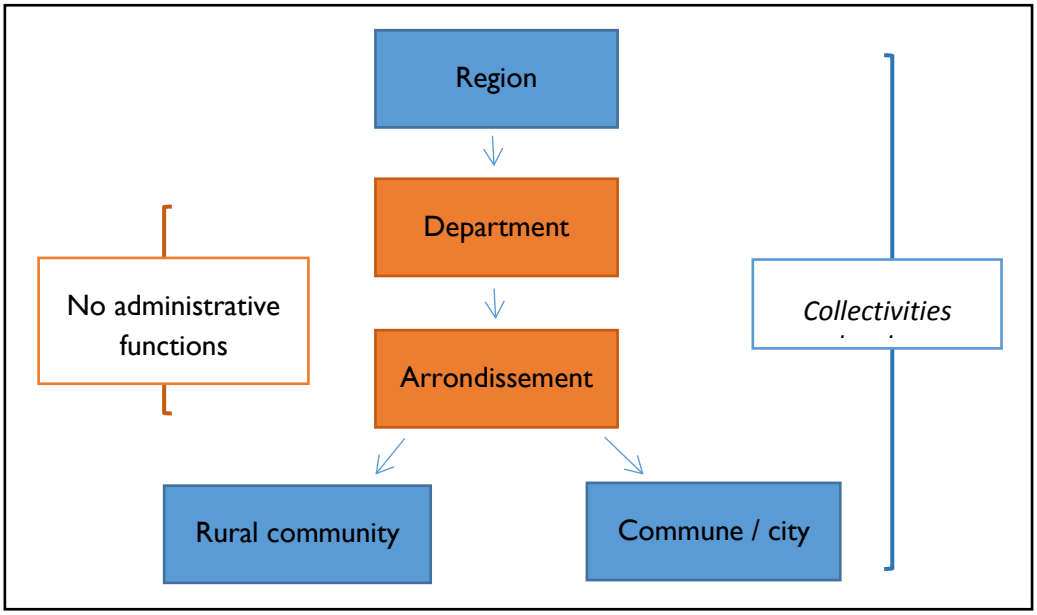
The following section explores the specific public, civic, and market institutions that play important roles in enabling adaptation at the local level in Senegal. However, before that detailed discussion, it is useful to locate Senegal's local institutions in the context of the country's national government structure and history of decentralization.

Government Structure of Senegal

Senegal comprises 10 administrative Regions headed by governors and appointed by the national government. Through the 1996 decentralization law (of which the secondary aim was to facilitate the optimization of NGOs' missions), the Region was created to be a focal point of development policy formulation, with Rural Communities implementing policies in rural areas and Communes implementing policies in urban areas. The term *Collectivités Locales* encompasses the Regions, *Ccommunautés Rurales* encompasses rural areas, and *Communes* encompasses urban areas.

Regions are also sub-divided into Departments and Arrondissements, neither of which have administrative functions. Technical Services exist at these levels — for instance the Service Department of Rural Development at the Department level, and the Centre for Local Development at the Arrondissement level — but these departments provide technical, not administrative, services and they report to the regional ministries. These Technical Services are described in greater detail in Section 5. Figure 2 depicts the basic decentralized government structure of Senegal.

FIGURE 2: PUBLIC ADMINISTRATIVE STRUCTURE OF SENEGAL



Decentralization in Senegal

Senegal has a long history of decentralization, dating back to the 1960s. In the 1990s, laws were put into place to implement the decentralization of power to different levels of government. For example, Law 96-07 of March 22, 1996 outlines how decentralization should occur in areas as varied as health and use of private property. However, the extent to which decentralization has effectively occurred in Senegal is unclear. A 2003 World Bank study rates Senegal with a 3 (on a scale of 0 to 4) for political decentralization, but only 1.2 (or 20th of the 30 countries sampled) for administrative decentralization (Ndegwa and Levy, 2003).

Decentralization ideally should empower local authority and encourage a greater density of local institutions; however, the benefits of a decentralized response to climate change impacts will be lost if the process of decentralization fails to truly transmit power to the local level, or if local institutions are hindered by a lack of resources, coordination, and capacity. This situation unfortunately has been the case in Senegal. The World Bank (2003) explains that Senegal does not adequately finance local-level public institutions: "the transfer of fiscal resources has been way below a level commensurate with the expanded scale of responsibilities" (Ndegwa and Levy, 2003). This issue has not improved with time.[1]

The 1996 law was followed by a planned distribution of powers in nine areas among regions, rural communities, and municipalities (FAO, n.d.; see Box 1); however, state funding only covers three of these — health, education and youth affairs — and the lack of financial provision for the other sectors inhibits the capacity of local government in those areas (World Bank, 2010). Rural Communities have very small budgets and limited capacity, which is often augmented by government functionaries called Community Assistants or sometimes Community Secretaries that are assigned to help them.

BOX 1: THE COMPETENCIES OVER WHICH THE RURAL COMMUNITIES SHARE JURISDICTION WITH THE STATE

- Land
- Territorial management
- Planning
- Youth, sports, and leisure
- Health, population, and social action
- Culture
- Urbanization and housing

The positive aspect of Senegal's decentralization process is that it has been slow and steady, and therefore not disruptive to the functioning of a country that has continued to make economic gains over time. An important social aspect of Senegal's decentralization is the alliance between politicians and bureaucrats, and the *marabout*-led Muslim *sufi* order (to which over 90 percent of the population belongs). This relationship contributes to the stability of civil society and helps to keep a check on the exercise of state power, but it does not support decentralization. The Muslim brotherhoods do not seem to engage in the policy discourse on decentralization; rather, they seek autonomy and access to state resources in return for securing legitimacy of the state (Ndegwa and Levy, 2003).

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[1] Unofficial Senegalese government estimates were that 80 to 100 billion West African CFA Francs (about 25 percent of consolidated public expenditures for the year 2000) were required to finance the expanded responsibilities. In practice, the total combined amount budgeted in 2000 was only 9 billion West African CFA Francs (less than 3 percent of consolidated expenditures). Commune-specific data suggested that the actual transferred amounts were not only below the allocated amount, but that they had declined after 1997 (Ndegwa and Levy, 2003).

The government is still trying to implement decentralization effectively. The following factors — several of which were confirmed in interviews conducted for this study — limit rural communities from capitalizing on their responsibilities in the decentralization process (UNDP and Government of Senegal, n.d.):

- a lack of commitment from elected officials to assume their new responsibilities;
- insufficient coordination between, and integration of, interventions;
- a lack of communication between staff;
- insufficient technical expertise at the local level;
- limited capacity to make decisions; and
- insufficient financial resources.

These insufficiencies have persisted despite many capacity-building efforts. UNDP and the Government of Senegal (n.d.) have recommended that provision of technical support, which is still focused on the regional level, should focus on the local level to help solve this problem.

5.0 INSTITUTIONS THAT MATTER FOR LOCAL-LEVEL ADAPTATION IN SENEGAL

This study divides local Senegalese institutions into three categories:

- Public Institutions: those set up within the existing government or governance structure, whether elected or appointed;
- Civic Institutions: nongovernmental organizations, hybrid organizations such as cooperatives, and other organizations that perform major functions related to provision of support during times of crises, facilitating social and cultural interactions and promoting social capital, and supporting the provision of social services and information; and
- Market Institutions: private sector organizations or institutions.

The institutions that matter for climate change adaptation, divided by category, are described in further detail below.

Public Institutions

Local-level public institutions are those set up within government or governance structures, whether elected or appointed. They include Rural Communities, national development agencies, and technical service providers. They are often the first line of contact between rural households or communities and the government, and are often responsible for providing basic services. Both these factors make them crucially important in helping respond to climate impacts.

Rural Communities and Village Associations

A Rural Community is made up of several villages from the same geographic area, and it is intended to be the main vehicle for provision of services and economic infrastructure (such as trucks and equipment). Each Rural Community is led by a Rural Council, and two-thirds of the members of the Rural Council are elected by the village constituents for five-year terms. The Rural Council is responsible for ensuring the implementation of the Local Development Plan (LDP) and coordinates a

range of development tasks including education, skill transfer, and awareness raising on issues related to agriculture, livestock, energy, housing, and infrastructure. Rural Councils share jurisdiction over nine competencies with the state (Box 1), but the real authority Rural Councils wield is limited since they only control the budget for three competencies – health, education, and youth affairs (FAO, 2006; Gellar, 2005). They are also often supported by Community Assistants (Box 2).

Village associations are also local-level informal institutions that play an important role in following through on projects implemented by external development agencies. For instance, in two projects implemented by the World Bank, village associations were the medium through which projects ensured sustainability over time (World Bank, n.d.1; World Bank, n.d.2). In one project, the village association provided guidance to the village members to run an ecotourism project to provide protection for the forest, where the source of income and protection of ecosystem services may have helped build adaptive capacity in the village.

BOX 2: ROLE OF COMMUNITY ASSISTANTS AND THE NACSS

Community Assistants support the Presidents of Rural Communities and are intended to bring a "touch of professionalism" to the administrative management of Rural Communities, which are often characterized by informality and a primarily oral tradition of communication (MDCL et al., 2008). Many Presidents of Rural Communities are illiterate and are appointed on a political basis. Community Assistants have been assigned to Rural Communities since 2002 to provide skills and to ensure the ability of the Rural Council to function well. Their roles include mobilizing state support for the functioning of Rural Communities, ensuring proper functioning of services, and following up on the commitments made by the Rural Council. They also prepare and present the budget, implement plans, and undertake daily management tasks (MDCL et al., 2008).

However, the role of Community Assistants is not secure within the Rural Community structure. For the past several years they have protested the lack of formality and security in their posts. The National Association of Community Secretaries of Senegal (NACSS) provides a means by which to make their case heard by the national government. Members of the NACSS have been trying to convince the national government that they provide invaluable services to the Rural Communities, and that they deserve a permanent status and more prestigious positions instead of year-long contracts and the support role of service providers (Diagne, 2009). The NACSS is also requesting the harmonization of wages for all Community Assistants (Thiès, 2012). In addition, there seems to be tension between Presidents of the Rural Communities and the Community Assistants who are posted to the Rural Communities. Some Presidents do not inform or involve the Community Assistants enough, and some Presidents want salaries that match those of the Community Assistants, which tend to be considerably higher than their own allowances (MDCL et al., 2008).

National Development Agencies

There is significant state involvement at the local level (World Bank, 2010). Two examples that demonstrate state involvement at the local level are the Project to Support Local Small-Scale Irrigation (PAPIL), executed by the Ministry of Agriculture and Water Resource Management in the Fatick, Kolda, and Tambacounda regions; and the Program on Sustainable and Participatory Energy Management (PROGEDE), which Ministry of Environment and Energy supervises. Both of these programs received funding from international sources and have several components that focus on provision of services and capacity building.

Another example is the Senegal River Delta Development and Exploitation Company (SAED) which is a state development corporation with a mandate focusing on water management. The goal of SAED's work is to improve the productivity of agriculture across the Senegal Valley and to control hydro-

agricultural development activities. The focus of SAED's work on land management, rural development, and maintenance of hydro-agricultural infrastructure makes it a potentially important player in strengthening the adaptive capacity of vulnerable people who live along the banks of the Senegal River. A non-academic "grassroots view" of Senegal River development agencies by anthropologist Adrian Adams (2000) highlights the lack of connection between SAED and the local communities, which could have implications for their programs on climate change adaptation.

Agricultural extension agencies play significant role at the local level, and often form the link between large-scale national-level efforts such as PAPIL and the implementation of projects and capacity building on the ground. The national government's creation of agricultural extension agencies began in 1985 through the Agricultural Extension Program (NAEP); in the 1990s, the government initiated the National Extension Services Agency (ANCAR), which had a focus on developing strong relationships with various stakeholders. This shift meant that the private sector, NGOs, and other farmer-based organizations all became important partners in the extension of agricultural services in the rural areas of Senegal (IFPRI, n.d.). Given the economic reliance of the country's population on agriculture, extension agencies have an important role to play in building communities' adaptive capacity.

Although the national government engages with local communities, primarily through projects, this effort does not reflect consistent vertical institutional integration of national support for adaptation across the country. Projects are time bound and often have a limited set of beneficiaries, and for some time periods and places the national government presence may be minimal. One indication of this inadequate national support is the lack of awareness of national policies at the local level, as seen with the National Adaptation Programme of Action (see Box 3).

BOX 3: THE ROLE OF NATIONAL-LEVEL INFORMATION FOR ADAPTATION AT THE LOCAL LEVEL

At the national level, Senegal completed its National Adaptation Programme of Action (NAPA) in 2006. The United Nations Environment Programme (UNEP) Final Evaluation of the Senegal NAPA notes that there was a good degree of country buy-in from the local to the national level, that the development of priority objectives was undertaken with the support of regional administrations and decentralized Technical Services, and that the NAPA is well-anchored within decentralized policies (UNEP, n.d.). While the NAPA seems to have been conceptualized within the decentralized government system, there seems to be a failure in communication of findings to all levels of the decentralized government. Almost all of the people who were interviewed as part of the ARCC Vulnerability Assessment for Senegal were unaware of the NAPA process, including those at the level of the Regional Directorate of Rural Development and the Service Department of Rural Development. For effective action at the local level, it would be highly beneficial for the NAPA to be linked to other frameworks (such as the poverty reduction framework and the legal, financial, and institutional frameworks of the country) but so far this linkage has been inadequately achieved (World Bank, 2010).

Technical Service Providers

A third set of public institutions that enable development at the local level is Technical Service agencies. These agencies provide technical expertise but do not have administrative duties. The interviews for the ARCC Vulnerability Assessment contain a range of Technical Service providers.

These include the Regional Directorate of Rural Development (DRDR) and the Service Department of Rural Development (SDDR), which carry out development efforts focused on agriculture and livestock at the regional and departmental levels, respectively (see Figure 2). The DRDRs in particular can play a role in climate change adaptation, as they have a regional weather service to prove early warning to farmers to help them adapt to climate variability. Informants suggest, however, that DRDRs do not have

a clear objective or plan to further expand climate concerns in their work. In addition to DRDRs and SDDRs, the Regional Directorate of Livestock and the Service Department of Livestock focus specifically on issues related to livestock such as vaccinations and fodder, and the Service Department of Agriculture focuses on issues related to farming such as seed varieties. Like the DRDR, the Centre for Local Development (CADL) works on issues of both agriculture and livestock, but at a district level. These Technical Service providers implement, monitor, and coordinate programs to improve farming and herding livelihoods.

Civic Institutions

Agarwal defines a civic institution as one that is "based in communities such as different kinds of self-help groups and nongovernmental organizations, and hybrid organizations such as cooperatives…[they] perform major functions related to provision of support during times of crises, facilitating social and cultural interactions and promoting social capital, helping mobilize collective action, and supporting the provision of social services and information…Though they do not have similar levels of resources as government agencies and organizations, their influence permeates rural life and interactions" (Agarwal, 2008).

Local CSOs, CBOs, and NGOs

Although civil society has existed since the colonial period in Senegal, it was not until the 1990s that civic institutions such as NGOs and women's groups began to gain recognition. Senegalese civic institutions (also called civil society organizations [CSOs]) play an active and dynamic role in the definition and implementation of public development policies. As intermediaries between the State and the citizens of Senegal, "CSOs have become indispensable in the deepening of participatory democracy and the defense of human rights, especially of the vulnerable groups (women, young people, the unemployed, children, prisoners, etc.)" (Kamara, 2010; Dyoulgerov, 2011). Similar to CSOs, community-based organizations (CBOs) act at the local level but have no formal status. CBOs are very widespread in Senegal, especially at the neighborhood level and in rural areas; however, there is no defined legal framework for these organizations (Kamara, 2010).

In Senegal, a variety of CBOs and CSOs are involved in local development and play a pivotal role in reducing household vulnerability (World Bank, n.d.). Community life is active in most towns and villages. In fact, "depending on their type and mandate, CBOs are actively supporting short and mid-term production or adaptation strategies in various areas. Generally, either in Senegal or elsewhere, CBOs mediate individual and collective responses for adaptation, and usually find themselves at the receiving end of external assistance geared towards implementing adaptation strategies." (World Bank, n.d.)

NGOs are declared, private, nonprofit associations or organizations that lend support to the development of Senegal and that are approved as such by the Government. According to the figures from the Directorate of Community Development of the Ministry of the Family, which oversees NGOs, some 487 approved NGOs are working in Senegal, of which 303 are national organizations and 184 are foreign organizations (Kamara, 2010). A major challenge for many CSOs seems to be self-sustainability. Access to financial resources is very limited in the Senegalese legal framework for the vast majority of the CSOs that do not have NGO status (Kamara, 2010).

Development Organizations

In addition to domestic CBOs, CSOs, and NGOs, international NGOs play an important institutional support role in Senegal. These include the international nonprofit organization ENDA LEAD, the French NGO Group of Research and Realization for Rural Development (GRDR), and USAID. Representatives from each of these international organizations were interviewed as part of the ARCC Vulnerability

Assessment study. Interviews revealed that none of them have programs that focus on adaptation. Interviewees specifically cited a lack of budget support for these activities, but representatives from all three organizations mentioned development activities that could contribute to building adaptive capacity.

For instance, ENDA mentioned training to build capacity and substitution of cattle with small ruminants such as goats and sheep, because they are more adaptable to scarcity of pasture and they reproduce faster. GRDR mentioned meetings that were organized to educate the population on seed varieties with shorter growing cycles. USAID's program, which focuses on malnutrition, also introduced seed varieties with shorter growing cycles and the creation of zai holes[2] to improve soil health. These organizations demonstrate a nascent approach to climate change readiness that is neither fully explicit nor fully articulated, and not yet integrated into the rest of their programming. These civic organizations also routinely collaborate with public institutions (Box 4), which could be an opportunity for advancing work on climate change at the local level.

Community-organized Associations

Partially to contend with the ineffectiveness of marketing associations, farmers set up farmer-based organizations and cooperatives. Through these associations, farmers seek help from both private and public institutions. Examples of these groups include the Walo Farmers' Association, the Bamba-Thialen group, and the Kabiline Group (IFPRI, n.d.). "Strong and active farmers' organisations are key institutions that bridge the gap between farmers, public research and extension bodies, government institutions and international donor organisations in making agricultural technology development more effective and relevant to farmers" (Hussein, n.d.)

Informal institutions also can provide efficient governance of shared resources through natural resource user groups and management associations. These may include water users associations, irrigation management associations, forest users groups, or fishery committees. These types of institutions increase in importance as resource scarcity or natural disasters caused by resource excess (e.g. flooding) can cause conflict at the community level. Having in place informal governance structures that are "owned" by the community members themselves can help mitigate this potential conflict (Speranza, 2010). Another example is smallholder irrigation systems, which are relatively free of political intervention and have low maintenance costs (Ngigi, 2009).

In order to gain better access to credit and savings, farmers also organize themselves into self-help groups. There are examples of indigenous forms of Self-Help Financial Groups (SHFG) across West Africa, such as Esusuor Susu in Nigeria and Ghana, Ekub in Ethiopia, and the Tontines in Cameroon and Niger. Over time, these indigenous self-help groups transform into formalized institutions such as Savings and Credit Organizations (SACCOs) (Speranza, 2010). Market institutions protect and support livelihoods by increasing production, trade, delivery of services, mobility, and employment – all of which can build the adaptive capacity of local communities (Agarwal et al., 2011). Many of the community-organized associations noted above are formed to enable or improve market functions that support natural resource based livelihoods. Such support to livelihoods based on ecosystem services, on which the majority of Senegal's population relies, will become more pronounced given the potentially negative future impacts of climate change. Other opportunities for market institutions, especially private enterprises, to engage in adaptation are highlighted below; however, thus far, private enterprises have played a minor role in adaptation at the local level in Senegal.

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2 A *zai* is a type of pit dug to retain water over dry periods.

Private Enterprises

In Senegal the private sector can play an important role in supporting farmer services. As mentioned in interviews with the market traders (Table 3), inadequate information about the state of transport infrastructure inhibit traders' ability to make decisions that maximize the profits they can get from selling their produce or livestock at markets. The private sector could finance and spread (and capitalize from) information communication technology, which could also help with preparedness of climate events. For instance, cell phones can be used to communicate to traders news about road closures due to flooding. Another avenue for potential engagement of the private sector is technology that would support year-round agriculture. Several of the interviews with traders highlighted the influx of produce from neighboring countries such as Mauritania during the summer in Senegal; crops in Mauritania tend to be irrigated, while crops in Senegal tend to be rain-fed.

BOX 4: PARTNERSHIPS BETWEEN CIVIC AND PUBLIC INSTITUTIONS

Agarwal (2008) notes that collaboration between civic and public institutions often facilitates adaptation to climate change. This was confirmed in interviews with international development agencies. ENDA LEAD reported that they work with the Service Department of Rural Development (SDDR), the GRDR contributes to the Local Development Plans (LDPs), and the USAID Yaajeende program works with Senegal's Institute for Agricultural Research (ISRA). These relationships were not discussed in detail in the interviews but could be a good avenue for integrating work focusing on adaptation at the local level.

This collaboration may be partially already occurring through CONGAD (Conseil des Organisations Non-Gouvernementales d'Appui au Développement, or Council of Non-Government Organizations in Support of Development), one of the larger nonprofit organizations in Senegal. An assembly of 161 domestic and international NGOs working in Senegal, CONGAD's mission is to play the role of an interface between the NGO movement, the government, CSOs, and partners in development. It accomplishes this goal through several mandates: the intensification of the institutional, organizational, and technical capacities of the CONGAD and its members; capitalization and sharing of the experiences of NGOs to make their actions visible; and promotion of political, economic, social, and cultural dialogue to influence national, African, and international public policies.

Marketing Associations

A market association enables interaction between farmers and wholesale traders who communicate with the farmers about urban consumers' preferences and about the prices their goods can fetch in the markets. However, cases of corruption and mismanagement of these institutions have made farmers wary of using them to support their livelihoods. The lack of institutional oversight allows for traders to continue exploiting farmers given the high costs of transporting goods to the market for individual farmers (Speranza, 2010). This implies that farmers are unable to get as much money for their produce and livestock as they are worth, which undermines their ability to develop and build adaptive capacity. Private sector enterprises can finance and provide technologies (such as information communication systems) that are reliable and trustworthy as a legitimate alternative to corrupt marketing associations.

6.0 SUMMARY OF FINDINGS

The following list summarizes findings from both the literature and the key informant interviews. The key informant interviews provided an in-depth look into 40 respondents' awareness of climate shocks, actions to contend with climate shocks and variability, and capacity to take such action. Table 3

summarizes the findings specifically from the key informant interviews; this table is organized according to research framework outlined in Table 2.

Almost all key informants are aware of climate shocks experienced in the recent past, but they are not aware of sources of information about climate variability and change (such as the country's National Adaptation Programme of Action or the United Nations Framework Convention on Climate Change). This lack of awareness of national and international processes indicates that national efforts have not reached the local level.

Local government (i.e., Rural Communities) does not have the resources required to support local-level adaptation, since Senegal's decentralization efforts have not succeeded in channeling adequate financial resources or capacity building efforts to the local level.

Community Assistants play an important role in increasing capacity of the Rural Communities; however, their short-term posts and resulting lack of job security inhibits their satisfaction with their jobs, which could in turn limit their ability to be effective at enabling adaptation.

The Local Development Plans are the major local planning vehicle and they outline the responsibilities of the Presidents of the Rural Communities and Community Assistants. However, they fail to incorporate information or actions that aid in contending with climate impacts.

Partnerships exist between development organizations such as ENDA and GRDR, as well as public organizations like the Technical Service providers and Presidents of Rural Communities, to implement development projects. Such partnerships between civic and public institutions play an important role in building capacity, and this type of public-civic partnership can be useful for enabling adaptation at the local level in Senegal.

When asked which institutions in Senegal should enable climate change adaptation at the local level, key informants most often highlighted national government and development actors; however, Senegal's push for decentralization indicates that local institutions such as Rural Communities and Technical Services would play an important adaptation role.

Development projects potentially build the adaptive capacity of communities through efforts such as improving nutrition, access to resources, and services such as livestock vaccinations; however, the project managers interviewed as part of this study had not intentionally incorporated climate risks or adaptation into their strategies. To facilitate future adaptation work in the study area, an evaluation of existing development projects could draw lessons about their role in building adaptive capacity and identify opportunities to enhance the adaptive role of similar future activities.

Few differences exist between the findings from departments in the North versus the South. Stakeholders have a similar awareness of climate shocks and threats (with rainfall being cited as a greater challenge in the South than in the North) and a similar lack of capacity in the North and South (with the Rural Communities in the South having slightly less capacity than those in the North). Additionally, there is little work being done to mitigate climate impacts in both the North and the South (with slightly more work reported in the South than in the North).

TABLE 3: FINDINGS FROM KEY INFORMANT INTERVIEWS ON CONTENDING WITH CLIMATE VARIABILITY AND EXTREMES[3]

Interviewees	Awareness of climate threats	Capacity	Current work on climate impacts
Rural Communities (Presidents and Community Assistants)	• Most of the interviewed Presidents and Community Assistants of the Rural Communities are aware of climate variability or shocks. • The types of noted climate impacts include poor rainfall, floods, high temperatures, and variable rainfall. • **North vs. South:** there is a similar awareness of climate threats and extremes in the North and South, as well as similar climate impacts. •	• There is a lack of resources for activities in general. Funds are supposed to be collected as taxes, but for the past several years they have remained unpaid. • Due to limited resources and capacity, addressing long-term climate change is not a priority. • Partnerships between Rural Communities and Development Projects increase the capacity of Rural Communities. • **North vs. South:** the South has slightly less capacity than the North.	• Limited resources inhibit Rural Communities from addressing problems that arise from climate variability or extremes. • In some cases, non-climate projects may be able to play a role in building adaptive capacity, but this potential must be evaluated. • **North vs. South:** there is very little work done on climate threats in both the North and South, but slightly more done in the South.
Interviewees	**Awareness of climate threats**	**Capacity**	**Current work on climate impacts**
Technical Service Providers (implement and monitor development	• All the interviewees were aware of climate variability or shocks, although in some interviews the awareness was implied, not directly stated.	• Every interview except one, which did not explicitly address capacity, mentioned constraints in capacity. These comments included human capacity to fill posts, financial means, and lack of materials such as vehicles	• There was very limited work on climate impact. Types of activities included guiding the selection of crops that were suitable to a changing climate, creating a regional weather service and early

[3] For a full list of interviewees, please see Annex G-1.

activities related to agriculture and livestock)	• The types of noted climate impacts include drought, high temperatures, variable rainfall, lack of rainfall, and floods. • North vs. South: there is similar awareness of climate threats and extremes in the North and South. The climate impacts are also similar, although rainfall was more of a concern in the South than in the North.	or refrigerators for storing vaccines. • Technical Services that focused on livestock and agriculture had similar capacity constraints. • North vs. South: There was a similar lack in capacity in the North and the South.	warning system, and using sandbags to prevent flooding. • North vs. South: Three of the five Technical Service providers in the North had no work and no provisions to work on climate concerns. In the South, none of the three Technical Service providers worked on climate concerns, except one that conducted awareness raising meetings.
Interviewees	**Awareness of climate threats**	**Work that could contribute to adaptation**	**Current work on climate impacts**
Development Project Managers (domestic and international NGOs, as well as state agencies that implement development projects and programs)	• All interviewees were aware of climate threats or shocks. Only in one interview was this awareness implicit but not explicitly stated. • The types of noted climate impacts include decrease in rainfall, floods, high temperatures, early arrival of cold temperatures and increased variability in rainfall. These impacts have manifested as drought. • **North vs. South:** there is similar awareness of climate threats in both the North and the South, and similar impacts are being felt.	• In all projects except one (PAPIL), specific activities that were mentioned could contribute to adaptation. These activities can be further separated by those that can help build adaptive capacity (e.g., poverty reduction); those that could help communities adapt to climate change over time (e.g., infrastructure projects that consider climate threats); those that could build awareness (e.g., through trainings); and those that could include adaptation in development plans or programs (e.g., through the Local Development Plan). • **North vs. South:** there was no meaningful difference between North and South.	• Some work is being undertaken to contend with climate impacts: two projects have no work in this area, two projects have some work in this area, and three projects have specific budget line items or programs dedicated to contending with climate impacts • In some instances, the interviewee would note that there is no specific budget line item for climate work, but that work that could contribute to adaptation is underway. • **North vs. South:** there was no meaningful difference between North and South.

Interviewees	Awareness of climate threats	Institutional needs identified	Changes in behavior due to climate
Market Traders (small-scale produce and livestock traders that sell their goods at markets)	• There was mixed awareness of climate threats among market traders. For instance, some were aware of climate threats, some did not think that climate change was a problem, and others thought this change was natural and that there was no need to adapt. • The types of noted climate impacts include high temperatures, decrease in rainfall, irregular rainfall, and extended summers. • **North vs. South:** there was no meaningful difference between North and South.	• Road infrastructure is lacking, which makes it challenging to get to markets. • Cost of transport is high. • Help should be given to farmers to manage the negative effects of flooding. • Storage to preserve produce is lacking. • There is a lack of fodder and water facilities for livestock. The vaccines do not seem to work and there is no enforcement against cattle rustling. • Seasonal migration forces people to leave their families behind. • **North vs. South:** there was no meaningful difference between North and South.	• Only one trader noted a change in behavior, which may be due to normal seasonal variation or recent climate threats (trying to sell less in the winter than in the summer). • Most traders denied making any changes in their behavior. • Three traders denied changing their behavior due to climate threats, but elsewhere in the interview these traders noted coping with climate shocks by reducing the amount they tried to sell or through seasonal migration. • **North vs. South:** there was no meaningful difference between North and South.

7.0 OPPORTUNITIES TO IMPROVE INSTITUTIONAL CAPACITY FOR ADAPTATION AT THE LOCAL LEVEL IN SENEGAL

Through the literature review and analysis of the key informant interviews, a set of four specific opportunities for enabling adaptation at the local level in Senegal became evident. These are described in the section immediately below. In the second sub-section, "Guide for Building Future Institutional Capacity," the framework for institutional readiness introduced in Section 2 is expanded upon and is included here as a potential way forward to improve institutional readiness for climate change adaptation in Senegal.

Specific Opportunities

The four specific opportunities for incorporating climate change into local level institutions are:

- the improved role that the Community Assistants may be able to play;
- the need for new Local Development Plans that incorporate climate change concerns;
- the potential contribution of development projects to contend with climate change; and
- the usefulness of partnerships between public and civic institutions.

Improved role of Community Assistants

As described in Box 2, Community Assistants bring technical expertise to the Rural Communities. However, the terms of their positions are not secure, and they have been trying to increase their job security through the formation of the NACSS and negotiations with the national government. If Community Assistants could be given greater job security in addition to training through the existing body of the NACSS, they could play an increasingly important role in building awareness around climate change issues and implementing interventions that build adaptive capacity or contend with specific climate impacts at the local level. They may be the vehicle through which the Rural Communities can improve their responsiveness to their constituents on issues related to natural resource management and livelihood security, which climate change will likely negatively impact in the coming decades.

Incorporating climate change into the Local Development Plan

The LDPs are used by the Rural Communities to inform the activities that they implement. Almost every interview with Rural Communities, either with the Presidents or Community Assistants, mentions the LDP. A few interviewees specifically raise the need for integrating climate change into the LDP, in order to ensure that future adaptation needs are met. In addition, some of the interviews with Technical Service providers and Project Managers of development projects also mention the LDP, since they often collaborate with the Rural Communities. Having climate change incorporated into the LDP may help ensure coordination of climate change related activities between both, the regional level and the local level, and between all the actors operating at the local level.

Assessing development projects for their role in contending with climate change

Many development initiatives are underway at the local level in Senegal and are undertaken by the Technical Service providers as well as both domestic and international development actors. These projects could be evaluated from a climate change perspective to assess if they have been contributing to building capacity to contend with future climate change. While it is not appropriate for all development projects to have a climate component, there may be an opportunity for some projects or programs to play a larger role in preparing communities for climate impacts in the future.

Enabling and improving partnerships between public and civic institutions

In addition to possible future partnerships between public and civic institutions, partnerships that already exist seem to be the means by which to best support adaptation at the local level. For instance, partnerships between Rural Communities and Technical Service providers, or implementers of development projects and farmer associations, have the benefit of drawing on the strengths of each partner and achieving more than a single entity would be able to achieve independently. The usefulness of the Council of Non-Government Organizations in Support of Development (CONGAD) might be a particular vehicle for enabling such collaboration on the issue of climate change in Senegal (see Box 4 for more information on CONGAD).

Guide for Building Future Institutional Capacity

In addition to the specific opportunities for improving the ability of local-level institutions to contend with climate change as noted above, there is a broader overarching need for improved capacity development to contend with climate change. In this section, the three main characteristics of institutional readiness (introduced in Section 2) are accompanied by questions that could be used to guide improvements in such capacity-building efforts.

- Whether the institution can manage information and knowledge to assess and prioritize climate risks:
  - Does the institution have access to climate information and the capacity to reformat this information to make it useful for its constituents?
  - Does the institution utilize scenarios or other techniques to contend with climate uncertainty and the risks associated with potential futures?
  - Does the institution have a clear knowledge management strategy to incorporate learning from previous adaptation interventions?
- Whether the institution is forward thinking in order to be flexible and innovative:
  - Does the institution plan against a long time horizon?
  - Does the institution have resources and capacities to respond quickly to an opportunity or a change in a situation?
  - Does the institution have the ability to change its work to incorporate new information or lessons learned along the way?
- Whether the institution is truly participatory in order to be responsive to the community within which it exists:
  - Does the institution periodically incorporate participation from the community?
  - Does the institution solicit participation from diverse sections of the community in appropriate ways?
  - Does the institution move beyond soliciting input to incorporating participation in its activities and decisions, thereby providing community members with active roles?

8.0 CONCLUDING REMARKS

Senegal's history of decentralization provides an opportunity for local-level institutions to play an increasingly important role in contending with climate change. However, since financial and human resources have not been fully transferred to the local level, there is limited autonomy or capacity for action by public institutions at the local level. If the role of the Community Assistants can be bolstered by the national government, and if additional capacity-building and resources become available, Rural Communities have the potential to play a much more active role in local-level adaptation.

In the literature, civic institutions were noted to play a central role in building adaptive capacity in Senegal. Since *access* to institutions has been identified as vital for households and communities in adopting adaptation strategies, civic institutions (which tend to have good outreach to households and communities) will continue to be important players in local adaptation decision-making. Collaborative efforts between civic and public institutions have the potential for effective adaptation interventions at the local level; however, as noted below, such collaboration needs to be explored further.

While market institutions have potential for building adaptive capacity, this potential has not been fully explored in Senegal. This is one area where extra-local agencies, such as international development agencies, may be able to play a particularly important role. For instance, extra-local agencies are likely to be attractive partners for the private sector, and such collaboration can work to secure livelihoods at risk to climate change. As recognized in Agarwal's framework of adaptation options, a focus on equity is particularly important in supporting market institutions.

Several avenues for future research could improve our understanding of the gaps and opportunities for institutions to support adaptation at the local level in Senegal. These include: understanding why key informant interviews did not identify local-level public or civic organizations as sources of support during periods of future climate variability or shocks; identifying one or two key partnerships between public and civic institutions that can enable adaptation and that could be used as examples for others to follow; and examining the specific entry points and policy processes by which climate change can be better integrated into Local Development Plans.

ANNEX G-1. NAMES OF INTERVIEWEES, THEIR INSTITUTION, AND LOCATION

Summary

	Matam	Kanel	Goudiry	Bakel	Total
Trader	3	2	2	3	11
TS	3	2	1	2	8
CR	4	4	5	2	15
NGO/Project	1	2	2	2	7
Total	**12**	**12**	**10**	**6**	**40**

Complete List

Name, Title of Interviewee	Interviewee type	Department/CR
Seck Thierno Bal, Responsable de Programme de Developpement Rural et Désertification, ENDA LEAD	Project	Bakel
Moustapha KA, Coordonnateur du GRDR Bakel	Project	Bakel
Seydou Ba, Chef SDDR	Technical Service	Bakel
Pape Mbaye DIAW, Chef de service départemental de l'élevage	Technical Service	Bakel
Niang, Trader	Trader	Bakel/Bondji
Diawara, Cattle Trader	Trader	Bakel/Bondji
Gandia, Produce Trader	Trader	Bakel/Bondji
Thiam, Ascom	Rural Community	Bakel/Gabou
Mbengue, Ascom	Rural Community	Bakel/Sinthiou Fissa
Ba, SDDR	Technical Service	Goudiry
Ndemane, Trader	Trader	Goudiry/Balla
Ba, Produce Trader	Trader	Goudiry/Balle
Dieng, PCR	Rural Community	Goudiry/Boynguel Bamba
Daouda Sow, PCR	Rural Community	Goudiry/Dougue
Baganda Sakho	Rural Community	Goudiry/Kaor

Dialy Diankha, PCR	Rural Community	Goudiry/Komoti
Abdoulaye Ka, PCR	Rural Community	Goudiry/Sinthiou Mamadou Boubou
Diao, Chef du Service d'Elevage	Technical Service	Kanel
Gueye, Chef Service Départementale de l'Agriculture	Technical Service	Kanel
Wone, PCR	Rural Community	Kanel/Aoure
Diop, Ascom	Rural Community	Kanel/Bokiladji
Mansour BEYE, Commercant de Cereals	Trader	Kanel/Orkadiere
Alassane Bousso, Produce Trader	Trader	Kanel/Orkadiere
Dia, Adjoint du Président de la délégation spéciale	Rural Community	Kanel/Ouro Sidi
Arona DIA, Représentant du PRODAM	Project	Kanel/Wedou Bosseabe
Mme Fatou Sall, Coordinatrice Yaajeende Matam	Project	Matam
Balde, Chef du CADL Matam	Technical Service	Matam
Ndong, Dir. Regional Elevage	Technical Service	Matam
Sene, Adjoint du Gov Gueye, Dir. de DRDR	Technical Service	Matam
Ba, Produce Trader	Trader	Matam
Diop, Produce Trader	Trader	Matam
Thimbo, Livestock Trader	Trader	Matam
Paul Mari FAYE, Coordinateur départemental, SAED	Project (Parastatal)	Matam and Kanel
Tierra, PCR Diagne, Assistant Communautaire	Rural Community	Matam/Bokidiawe
Ba, Assistant Communautaire	Rural Community	Matam/Nabadji Civol
Niang, Cereal Trader	Trader	Matam/Nabadji civol
Amadou Thiam, PCR Ogo	Rural Community	Matam/Ogo
PCR, Ndiaye Ascom, Niang	Rural Community	Matam/Orefunde
Agnes Daba Thiaw, Responsable d'encadrement et formation, PROGEDE	Project	Tamba
Sedar Ngom, Chef d'antenne de Tamba, PAPIL	Project	Tamba

ANNEX G-2. KEY INFORMANT INTERVIEW QUESTIONNAIRES

Annex G-2.1: Questionnaire for Rural Community Presidents and Community Assistants

Remarques à l'intention de l'animateur/du rapporteur : Introduction, explication du but, comment les informations seront utilisées, etc. (lettre d'introduction d'une page rédigée par l'ISRA).

Notes to the facilitator/reporter: Introduction, explanation of the intent, how the information will be used, etc. (one-page letter of introduction written by ISRA)

Nom de l'enquêteur :

Name of the interviewer:

Nom du rapporteur :

Name of the facilitator/reporter

Date:

Nom de la communauté rurale (CR):

Name of the rural community (CR):

Lieu de l'interview:

Location of the interview:

Nom de la(les) personne(s) interrogée(s):

Name of the persons interviewed

Titre:

Title

1. DESCRIPTION DES RESPONSIBILITÉS DU TRAVAIL

   Descriptions of work responsibilities

   a) Brève description de vos responsabilités en tant que membres du conseil rural

   Brief description of your responsilbilities as a member of the rural council

   b) Quelles sont les principales priorités de votre CR en ce moment ?

   What are the priority principals for your CR at this moment?

   c) Comment votre CR s'occupe-t-elle de ces priorités ?

   How does your CR deal with these priorities?

   d) A votre avis, avez-vous atteint vos objectifs en ce qui concerne ces priorités ?

   In your opinion, did you achieve your goals with regard to these priorities?

2. IMPACT DU CLIMAT

Climate Impact

a) Quels événements climatiques ont eu le plus grand impact sur la population de votre CR au cours de ces dernières années?

What climate events have the greatest impact on the population of your CR in recent years?

Type d'événement/changement : Décrire le changement/l'événement

Type of event/change: Describe the change/event

Impacts: Décrire les impacts concrets sur les ménages/l'élevage/l'agriculture

Impacts: Describe the specific impacts on households/farming/agriculture

[a) sécheresse b) inondation c) changements dans les fréquences des précipitations d) températures plus élevées e) vents f) autre (précisez)]

[a) dryness b) flooding c) changes in the frequency of precipitation d) higher temperatures e) winds f) other (specify)]

3. PLANIFICATION ET ACTIONS RELATIVES AUX EVENEMENTS CLIMATIQUES

Planning and actions related to climate events

a) Comment la CR aborde-t-elle les effets négatifs du climat dans ses activités et programmes ?

How does CR address the negative effects of climate in its activities and programs?

b) La CR a-t-elle actuellement des projets ou des initiatives concernant les effets négatifs du climat?

Does the CR currently have projects or initiatives on climate impacts?

c) Le Conseil Rural s'est-il engagé dans les exercices ou ateliers de planification relatifs aux effets négatifs du climat?

Has the Rural Council engaged in exercises or planning workshops related to climate impacts?

d) Les *services techniques* font-ils actuellement face aux effets négatifs du climat dans votre CR ?

Do technical services currently face the negative effects of climate in your CR?

4. NIVEAU DE SENSIBILISATION ET DE COMPREHENSION DU CHANGEMENT CLIMATIQUE

Level of awareness and understanding of climate change

a) Que comprenez-vous du changement climatique?

What do you understand about climate change?

b) Quelles sont les preuves du changement climatique dans votre CR?

What is the evidence of climate change in your CR?

c) Avez-vous consulté le Programme d'Action National pour l'Adaptation aux Changements Climatiques (PANA) ou les Communications Nationales du Sénégal - Convention Cadre des Nations Unies sur les Changements Climatiques (CCNUCC) ?

Have you consulted the National Programme of Action for Climate Change Adaptation (NAPA) or the National Communications Senegal - United Nations Framework Convention on Climate Change (UNFCCC)?

SI OUI : Comment ces documents sont-ils intégrés dans la planification et les priorités de votre CR?

IF YES: How are these documents integrated into the planning and priorities of your CR?

5. RÉPONSES AUX ÉVÉNEMENTS ET CHANGEMENTS CLIMATIQUES

Responses to climate change and events

a) Sur la base de l'expérience récente, que fait votre CR pour atténuer les impacts négatifs du changement climatique ?

Based on recent experience, what does your CR do to mitigate the negative impacts of climate change?

b) En dehors du financement, quelles sont les principales contraintes auxquelles vous faites face dans la lutte contre les impacts du changement climatique ?

Apart from funding, what are the main constraints you face in the fight against the impacts of climate change?

Annex G-2.2: Questionnaire for Technical Service Providers

Remarques à l'intention de l'animateur/du rapporteur : Introduction, explication du but, comment les informations seront utilisées, etc. (lettre d'introduction d'une page rédigée par l'ISRA.

Notes to the facilitator / reporter: Introduction, explanation of the intent, how the information will be used, etc. (one-page letter of introduction written by ISRA)

Nom de l'enquêteur:

Name of the interviewer:

Nom du rapporteur:

Name of the writer/reporter:

Lieu de l'interview:

Location of the interview:

Date:

Date:

Nom du Département:

Name of the Department:

Nom de la personne interrogée:

Name of the interviewee:

Titre:

Title:

1. DESCRIPTION DES RESPONSIBILITÉS DU TRAVAIL

Description of work responsibilities

a) Comment décririez-vous les tâches et les activités principales sur lesquelles vous passez la plupart de votre temps ?

How would you describe the main tasks and activities that you spend most of your time on?

b) Quels sont les plus grandes priorités que votre service/institution traite en ce moment ? [pas nécessairement liés au climat]

What are the priorities that your service / institution deals with right now? [not necessarily related to climate]

c) Que faites-vous actuellement pour régler ces priorités?

What are you currently doing to address these priorities?

d) A votre avis, avez-vous atteint vos objectifs en ce qui concerne ces priorités ? (Expliquez pourquoi)

In your opinion, did you achieve your goals with regard to these priorities? (Explain why)

2. IMPACTS DU CLIMAT

a) Quels événements météorologiques ont eu le plus grand impact sur la population du département au cours de ces dernières années?

What weather events had the greatest impact on the population of the department in recent years?

Type d'événement: Décrire le changement/l'événement

Type of Event: Describe the change/event

Impacts: Décrire les impacts concrets sur les ménages/l'élevage/l'agriculture

Impacts: Describe the specific impacts on households / farming / agriculture

[a) sécheresse b) inondation c) changements dans les fréquences des précipitations d) températures plus élevées e) vents f) autre (précisez)]

[a) dryness b) flooding c) changes in precipitation frequency d) higher temperatures e) winds f) other (specify)]

3. RÉPONSES AUX EFFETS NÉGATIFS DU CHANGEMENT CLIMATIQUE

Answers to negative effects of climate change

a) Comment votre service ou institution a fait face aux effets négatifs?

How has your department or institution faced the negative effects of climate change?

b) En dehors du financement, quelles sont les principales contraintes auxquelles vous faites face dans la lutte contre les effets négatifs du changement climatique ?

Apart from funding, what are the main constraints you face in the fight against the negative effects of climate change?

c) D'après votre expérience, pouvez-vous identifier les moyens par lesquels la population du département s'est ajustée aux effets négatifs du changement climatique?

From your experience, can you identify the means by which the department's population has adjusted to the adverse effects of climate change?

d) Connaissez-vous d'autres institutions qui font face aux effets négatifs du changement climatique dans le département? Si oui, lesquelles?

Do you know of other institutions that face negative effects of climate change in the department? If so, which?

4. NIVEAU DE SENSIBILISATION ET DE COMPREHENSION DU CHANGEMENT CLIMATIQUE

Level of awareness and understanding of climate change

a) Que comprenez-vous du changement climatique?

What do you understand about climate change?

b) Quelles sont les preuves du changement climatique dans votre département ?

What evidence do you see of climate change in your department?

c) Avez-vous consulté le Programme d'Action National pour l'Adaptation aux Changements Climatiques (PANA) ou les Communications Nationales du Sénégal - Convention Cadre des Nations Unies sur les Changements Climatiques (CCNUCC) ?

Have you consulted the National Programme of Action for Climate Change Adaptation (NAPA) or the National Communications Senegal - United Nations Framework Convention on Climate Change (UNFCCC)?

SI OUI : Comment ces documents sont-ils intégrés dans la planification et les priorités de votre bureau ?

IF YES: How are these documents integrated into the planning and priorities of your office?

5. PLANIFICATION ET ACTIONS RELATIVES AU CHANGEMENT CLIMATIQUE

Planning and action on climate change

a) Comment votre bureau aborde-t-il le problème du changement climatique dans vos programmes d'action ?

How does your office address the problem of climate change in your action programs?

b) Votre bureau a-t-il alloué des personnes et un budget spécifique aux impacts ou effets du changement climatique ?

Has your office allocated a specific budget and/or specific people for climate change impacts or effects?

c) Votre service ou institution s'est-il engagé dans les exercices ou ateliers de planification relatifs au changement climatique ?

Has your department or institution engaged in exercises and planning workshops on climate change?

6. Serait-il possible d'avoir une copie de votre planification au changement climatique ?

Is it possible to have a copy of your climate change plan?

[Enregistrez le plan sur une clé USB si le plan est disponible.]

[Register plan on a USB stick if the plan is available.]

Annex G-2.3: Questionnaire for Development Actors

Remarques à l'intention de l'animateur/du rapporteur : Introduction, explication du but, comment les informations seront utilisées, etc. (lettre d'introduction d'une page rédigée par l'ISRA).

Notes to the facilitator/reporter: Introduction, explanation of the intent, how the information will be used, etc. (one-page letter of introduction written by ISRA)

Nom de l'enquêteur:

Name of the interviewer:

Nom du rapporteur:

Name of the writer/reporter:

Date:

Date:

Nom du Departement

Name of the Department:

Zone d'intervention:

Area of the intervention:

Lieu de l'interview:

Location of the interview:

Nom de la personne interrogée:

Name of the person interviewed:

Titre:

Title:

7. DESCRIPTION DES RESPONSIBILITÉS DU TRAVAIL

Description of responsibilities of your work

a) Brève description de la mission et les objectifs de votre projet

Brief description of the mission and objectives of your project

b) Que fait votre organisation pour atteindre ces objectifs ?

What does your project do to meet these objectives?

c) A votre avis, comment votre organisation ou projet est-il en mesure d'atteindre ces objectifs?

In your opinion, how is your organization or project able to meet your objectives?

8. IMPACTS DU CLIMAT

Climate impacts

Quels événements négatifs du climat ont eu le plus grand impact sur la population au niveau de votre zone d'intervention au cours de ces dernières années?

What negative climate events have had the greatest impact on the population in your area of intervention in recent years?

Type d'événement/changement: Décrire le changement/l'événement

Type of event/change: Describe the change/event

Impacts: Décrire les impacts concrets sur les ménages/l'élevage/l'agriculture

[a) sécheresse b) inondation c) changements dans les fréquences des précipitations d) températures plus élevées e) vents f) autre (précisez)]

[a) dryness b) flooding c) changes in precipitation frequency d) higher temperatures e) winds f) other (specify)]

9. RÉPONSES AUX EFFETS NÉGATIFS DU CLIMAT

Responses to the negative effects of climate change

a) Comment votre projet fait-il face aux effets négatifs du climat ?

How does your project deal with the adverse effects of climate change?

b) En dehors du financement, quelles sont les principales contraintes auxquelles vous faites face dans la lutte contre les effets négatifs du climat?

Apart from funding, what are the main constraints you face in the fight against the negative effects of climate?

c) D'après votre expérience, pouvez-vous identifier les moyens par lesquels la population du département s'est ajustée aux effets négatifs du climat?

From your experience, can you identify the means by which the population in your department has adjusted to the adverse effects of climate change?

d) Connaissez-vous d'autres institutions qui font face aux effets climatiques dans le département? Si oui, lesquelles ?

Do you know of other institutions that deal with climate effects in the department? If so, which?

10. NIVEAU DE SENSIBILISATION ET DE COMPREHENSION DU CHANGEMENT CLIMATIQUE

Level of awareness and understanding of climate change

a) Que comprenez-vous du changement climatique?

What do you understand about climate change?

b) Quelles sont les preuves du changement climatique dans votre département ?

What evidence of climate change do you see in your department?

c) Avez-vous consulté le Programme d'Action National pour l'Adaptation aux Changements Climatiques (PANA) ou les Communications Nationales du Sénégal - Convention Cadre des Nations Unies sur les Changements Climatiques (CCNUCC) ?

Have you consulted the National Programme of Action for Change Adaptation Climate Change (NAPA) or the National Communications Senegal - United Nations Framework Convention on Climate Change (UNFCCC)?

SI OUI : Comment ces documents sont-ils intégrés dans la planification et les priorités de votre projet?

IF YES: How are these documents integrated into the planning and priorities of your project?

11. PLANIFICATION ET ACTIONS RELATIVES AU CHANGEMENT CLIMATIQUE

Planning and action on climate change

a) Comment votre projet aborde-t-il le problème du changement climatique dans vos programmes d'action ?

How does your project address the problem of climate change in your action programs?

b) Votre projet a-t-il alloué des personnes et un budget spécifique aux impacts ou effets du changement climatique?

Does your project allocate specific people and budget for climate change impacts or effects?

c) Votre projet s'est-il engagé dans les exercices ou ateliers de planification relatif au changement climatique ?

Is your project engaged in exercises or planning workshops on climate change?

12. RÉPONSES AU CHANGEMENT CLIMATIQUE

Reponses to Climate Change

a) comment votre projet a-t-il pris en compte les effets négatifs du changement climatique ?

How does your project take into account the negative effects of climate change?

b) En dehors du financement, quelles sont les principales contraintes auxquelles vous faites face dans la lutte contre les impacts ou effets du changement climatique ?

Apart from funding, what are the major constraints you face in the fight against the impacts or effects of climate change?

c) D'après votre expérience, pouvez-vous identifier les moyens par lesquels la population du département s'est ajustée aux impacts ou effets du changement climatique ?

From your experience, can you identify the means by which the population of the department has adjusted the impacts or effects of climate change?

d) Etes-vous au courant d'autres institutions qui font face au changement climatique dans le département? Si oui, laquelle ?

Are you aware of other institutions that deal with climate change in the department? If yes, which?

13. Serait-il possible d'avoir une copie du plan d'action de votre projet ?

Is it possible to have a copy of the action plan of the project?

[Enregistrez le plan sur une clé USB si le plan est disponible.]

[Register plan on a USB stick if the plan is available.]

Annex G-2.4: Questionnaire for Market Vendors

Remarques à l'intention de l'animateur/du rapporteur : Introduction, explication du but, comment les informations seront utilisées, etc. (lettre d'introduction d'une page rédigée par l'ISRA).

Notes to the facilitator/reporter: Introduction, explanation of the intent, how the information will be used, etc. (one-page letter of introduction written by ISRA)

Nom de l'enquêteur:

Name of the interviewer:

Nom du rapporteur:

Name of the writer/reporter:

Lieu de l'interview:

Location of the interview:

Date:

Date :

Nom du Département:

Name of the Department:

Nom de la personne interrogée:

Name of the interviewee:

Titre:

Title :

14. DESCRIPTION DES RESPONSIBILITÉS DU TRAVAIL

Description of work responsibilities

a) Comment décririez-vous les tâches et les activités principales sur lesquelles vous passez la plupart de votre temps ?

How would you describe the main tasks and activities that you spend most of your time on?

b) Quels sont les plus grandes priorités que votre service/institution traite en ce moment ? [pas nécessairement liés au climat]

What are the priorities that your service / institution deals with right now? [not necessarily related to climate]

c) Que faites-vous actuellement pour régler ces priorités?

What are you currently doing to address these priorities?

d) A votre avis, avez-vous atteint vos objectifs en ce qui concerne ces priorités ? (Expliquez pourquoi)

In your opinion, did you achieve your goals with regard to these priorities? (Why)

15. IMPACTS DU CLIMAT

Impacts of climate change

a) Quels événements météorologiques ont eu le plus grand impact sur la population du département au cours de ces dernières années?

What weather events had the greatest impact on the population of the department in recent years?

Type d'événement: Décrire le changement/l'événement

Type of Event: Describe the change / event

Impacts: Décrire les impacts concrets sur les ménages/l'élevage/l'agriculture

Impacts: Describe the specific impacts on households / farming / agriculture

[a) sécheresse b) inondation c) changements dans les fréquences des précipitations d) températures plus élevées e) vents f) autre (précisez)]

[a) dryness b) flooding c) changes in precipitation frequency d) higher temperatures e) winds f) other (specify)]

16. RÉPONSES AUX EFFETS NÉGATIFS DU CHANGEMENT CLIMATIQUE

Answers to negative effects of climate change

a) Comment votre service ou institution a fait face aux effets négatifs?

How has your department or institution faced the negative effects of climate change?

b) En dehors du financement, quelles sont les principales contraintes auxquelles vous faites face dans la lutte contre les effets négatifs du changement climatique ?

Apart from funding, what are the main constraints you face in the fight against the negative effects of climate change?

c) D'après votre expérience, pouvez-vous identifier les moyens par lesquels la population du département s'est ajustée aux effets négatifs du changement climatique?

From your experience, can you identify the means by which the department's population has adjusted to the adverse effects of climate change?

d) Connaissez-vous d'autres institutions qui font face aux effets négatifs du changement climatique dans le département? Si oui, lesquelles ?

Do you know of other institutions that face negative effects of climate change in the department? If so, which?

17. NIVEAU DE SENSIBILISATION ET DE COMPREHENSION DU CHANGEMENT CLIMATIQUE

Level of awareness and understanding of climate change

a) Que comprenez-vous du changement climatique?

What do you understand about climate change?

b) Quelles sont les preuves du changement climatique dans votre département ?

What evidence do you see of climate change in your department?

c) Avez-vous consulté le Programme d'Action National pour l'Adaptation aux Changements Climatiques (PANA) ou les Communications Nationales du Sénégal - Convention Cadre des Nations Unies sur les Changements Climatiques (CCNUCC) ?

Have you consulted the National Programme of Action for Climate Change Adaptation (NAPA) or the National Communications Senegal - United Nations Framework Convention on Climate Change (UNFCCC)?

SI OUI : Comment ces documents sont-ils intégrés dans la planification et les priorités de votre bureau ?

IF YES: How are these documents integrated into the planning and priorities of your office?

18. PLANIFICATION ET ACTIONS RELATIVES AU CHANGEMENT CLIMATIQUE

Planning and Action on climate change

a) Comment votre bureau aborde-t-il le problème du changement climatique dans vos programmes d'action ?

How does your office addresses the problem of climate change in your action programs?

b) Votre bureau a-t-il alloué des personnes et un budget spécifique aux impacts ou effets du changement climatique ?

Has your office allocated a specific budget and/or specific people for climate change impacts or effects?

c) Votre service ou institution s'est-il engagé dans les exercices ou ateliers de planification relatifs au changement climatique ?

Has your department or institution engaged in exercises and planning workshops on climate change?

19. Serait-il possible d'avoir une copie de votre planification au changement climatique ?

Is it possible to have a copy of your climate change plan?

[Enregistrez le plan sur une clé USB si le plan est disponible.]

[Register plan on a USB stick if the plan is available.]

ANNEX G-3. COMPARISON OF SENEGAL TO OTHER COUNTRIES

This annex provides a comparison of Senegal to other countries in West Africa in regard to climate impacts, adaptation strategies, and institutional access (Agarwal et al., 2011).

FIGURE 7. AVERAGE NUMBER OF INSTITUTIONS ACCESSED BY HOUSEHOLDS IN WEST AFRICA

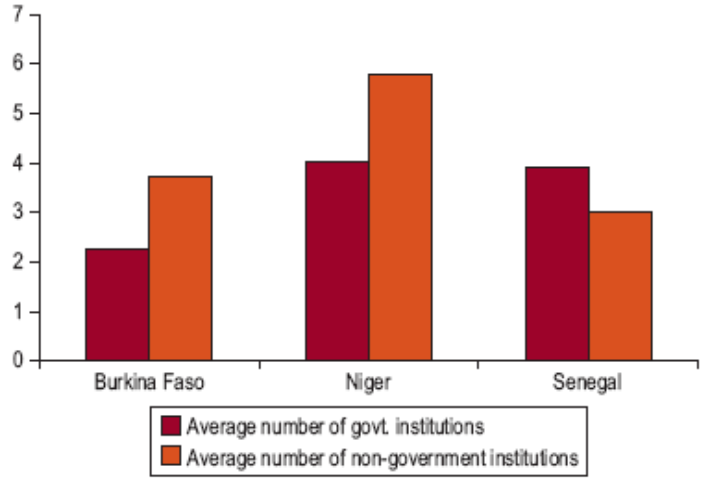


FIGURE 8. RECENT HAZARDS EXPERIENCED BY HOUSEHOLDS IN WEST AFRICA

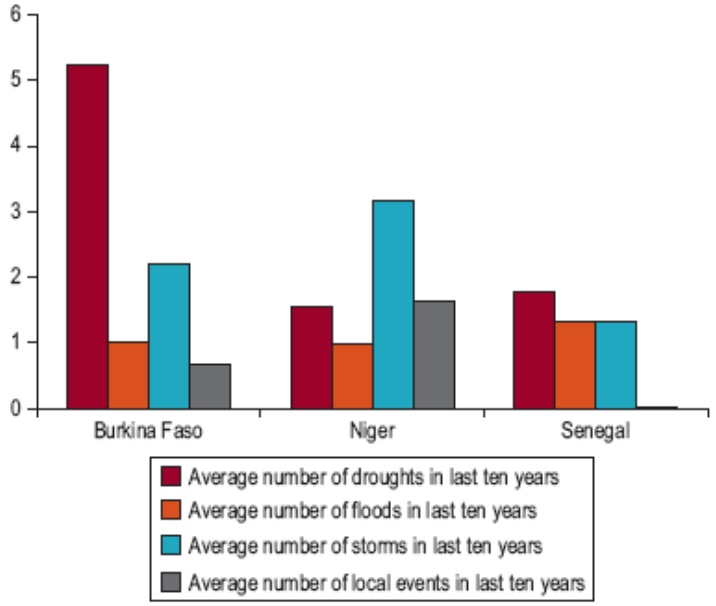


FIGURE 12. DIVERSITY OF ACCESS TO INSTITUTIONS AND INFORMATION SOURCES FOR WEST AFRICAN HOUSEHOLDS

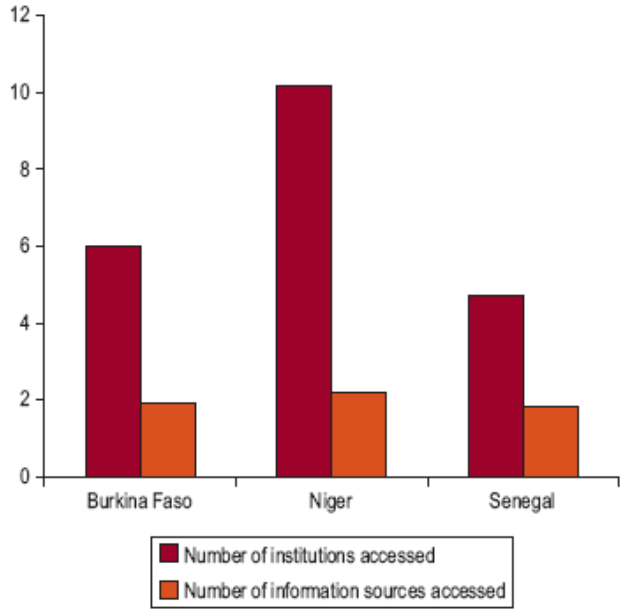
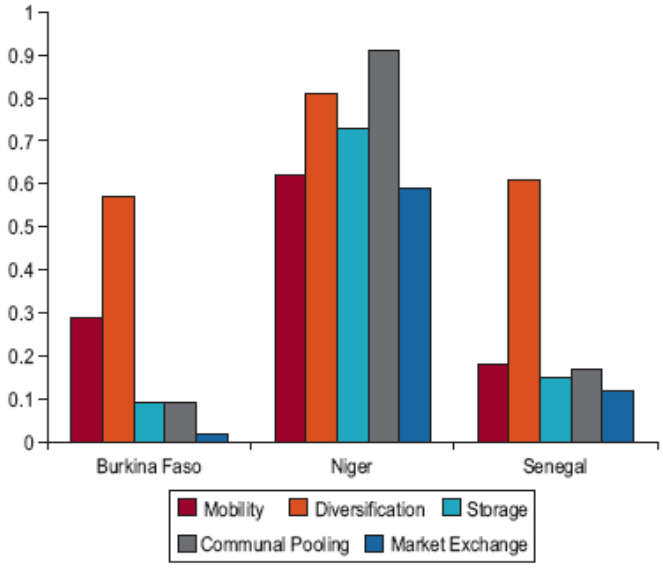


FIGURE 13. ADAPTATION STRATEGIES PRACTICED BY PROPORTION OF INTERVIEWED HOUSEHOLDS IN WEST AFRICAN COUNTRIES



ANNEX G-4. CHARACTERISTICS

The characteristics put forth in this paper as most important for institutions building adaptive capacity at the local level are:

- *whether the institution can manage information and knowledge to assess and prioritize climate risks;*
- *whether the institution is forward thinking to be flexible and innovative; and*
- *whether the institution is truly participatory to be responsive to the community within which it exists.*

The characteristics have been distilled from characteristics described in three existing frameworks – the ACCRA Local Adaptive Capacity Framework (ACCCRA, n.d.), the World Resources Institute's (WRI's) National Adaptive Capacity Framework (Dixit et al., 2011), and WRI's 2010-2011 World Resources Report on Decision Making in a Changing Climate (WRI, 2011). The characteristics in italics below have been incorporated into the framework created for this paper. Noting the significant overlap of these frameworks, the three main characteristics not included in the framework created for this paper are: asset base, institutions and entitlements, and coordination.

Characteristics from the ACCRA Local Adaptive Capacity Framework

- Asset base
- Institutions and entitlements
- Knowledge and information
- Innovation
- Flexible, forward-thinking decision-making and governance

Characteristics from the WRI National Adaptive Capacity Framework

- Assessment
- Prioritization
- Coordination
- Information management
- Climate risk reduction

Characteristics from the WRI World Resources Report Framework

- ***Flexible***
- ***Coordinated***
- ***Transparent and participatory***
- ***Forward thinking***
- ***Risk oriented***

ANNEX G-5. LIST OF ACRONYMS IN ANNEX G

ANCAR	National Extension Services Agency
ARCC	African and Latin American Resilience to Climate Change
CADL	Center for Local Development
CBO	Community-Based Organization
CONGAD	Council of Non-Government Organizations in Support of Development
CSO	Civil Society Organization
DRDR	Regional Directorates of Rural Development
GRDR	Group of Research and Realization for Rural Development
ISRA	Senegal's Institute for Agricultural Research
LDP	Local Development Plan
NAEP	Agricultural Extension Program
NAPA	National Adaptation Programme of Action
NACSS	National Association of Secretaries Community of Senegal
NGO	Nongovernmental Organization
PAPIL	Project to Support Small Irrigation Local
PROGEDE	Program on Sustainable and Participatory Energy Management
SAED	Senegal River Delta Development and Exploitation Company
SACCOs	Savings and Credit Organizations
SDDR	Service Department of Rural Development
SHFG	Self-Help Financial Groups
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development

ANNEX G-6. REFERENCES

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ANNEX H. CHANGEMENTS CLIMATIQUES ET REPONSES LOCALES DANS LA REGION EST DU SENEGAL ET AU SAHEL

APPRENDRE DES SECHERESSES PASSEES POUR MIEUX S'ADAPTER

Dr Henri M. Lo, Mor Sèye Fall et Cheikh.T. Dièye

Executive Summary (English)

The Sahel and West Africa are classified by the Intergovernmental Panel on Climate Change (IPCC) as among the regions the most vulnerable to future climate change. Drought conditions are likely to intensify, along with the consequences that are known to accompany them. While drought is certainly not a new phenomenon to the Sahel—the 1970s and 1980s remain engraved in collective memory as periods of great misery, characterized by famines and recurring food shortages after the devastation of crops and the annihilation of livestock—under climate change such high variability of rainfall is expected to be aggravated by increased temperatures. These increases could have considerable additional impact on crop production, animal health, and communities.

The question at the core of this paper is: How did the Sahelian communities survive these periods of intense drought and, facing similar trends, what lessons can we draw from the strategies they implemented to adapt?

Evidence from literature suggests that the responses adopted by the Sahelian public, particularly in the domains of agriculture and animal husbandry, were varied. Responses included diversifying the crops cultivated; selling and consuming wild products; increasing small-scale animal husbandry; and undertaking petty trade and new trades (carpentry, blacksmithing, crafts etc.). Strategies also included mobility, the essential resource of herders, who seem to have borne the highest burden, and migration, which was undertaken by all.

Farmers developed technological innovations that, with the support of scientific research, seem to have produced positive results such that they continue to be used to fight against climate variability and extremes. Among others, they include: varietal adaptation, and soil and water management practices.

In response to the droughts, herders intensified the use of strategies naturally inherent in this approach to production. Their innovations centered on the core strategy of mobility and included fundamental changes in managing feed and fodder; usage of substitution plants to compensate for food deficits; storage of food that, for herders, is the accumulation of live animals; the dispersion of livestock, often in the form of livestock loan; and the diversification of animal species raised for the best usage of environmental resources but also the diversification risk. They also have practiced controlling animals' gestation cycles, reflecting their deep knowledge of their animals.

However, will these practices and techniques, which were more or less efficient means to survive the droughts, be sufficient when facing climate change of which the magnitude and intensity is likely to increase tenfold? If these agricultural and pastoral practices seem more or less proven in terms of variability, what will be the limits of these local responses to the more structural changes in climate, especially at the long-term temperature and rainfall levels? We must learn to analyze the local experiences of fighting against drought and take the greatest possible advantage of lessons learned for sustainable adaptation, which impacts not only communities, but all the countries of the Sahel, as well as their internal and external partners.

Résumé exécutif

Le Sahel et l'Afrique de l'Ouest sont classés par le Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC), parmi les régions les plus vulnérables aux changements climatiques futurs. Les sécheresses, une des principales manifestations de ces dérèglements climatiques, vont vraisemblablement connaître une recrudescence avec le lot de conséquences qu'on leur connaît.

Ces modifications du climat ne sont certes pas un phénomène nouveau ; les années 1970 et 1980 notamment, restent gravées dans la mémoire collective, comme des périodes de grande misère marquées par des famines et disettes récurrentes, suite au déclin vertigineux de l'agriculture et à l'anéantissement des troupeaux. Cependant, la forte variabilité des précipitations qui a été l'une des caractéristiques majeures de ces sécheresses, se combine, dans le contexte des changements climatiques, à des températures en constante hausse, qui pourraient avoir un impact considérable non seulement sur les rares précipitations qui vont tomber et sur l'assèchement et la dégradation des terres, mais aussi sur la santé humaine et animale.

La question principale au centre de ce papier, est : comment les communautés sahéliennes ont elles survécu aux périodes dramatiques de sécheresse qu'elles ont vécues et, face à des tendances actuelles similaires, quelles leçons tirer des stratégies de lutte mises en œuvre, pour s'adapter aux changements climatiques ?

Il ressort de la littérature que les réponses apportées par les populations sahéliennes, notamment dans les domaines de l'agriculture et de l'élevage, sont variées. Ces réponses tournent autour de la diversification des cultures, la cueillette de feuilles et fruits sauvages pour compenser le déficit de nourriture, le petit élevage, l'exercice de petit commerce et de nouveaux métiers (gardiennage, artisanat, forge, etc.) mais aussi la mobilité, levier essentiel de l'adaptation chez les éleveurs qui semblent avoir payé le plus lourd tribut et la migration qui touche beaucoup plus les agriculteurs.

Les agriculteurs ont mis au point de nombreuses innovations technologiques qui, grâce à l'appui de la recherche scientifique semblent avoir produit des résultats intéressants au point d'être reconduites pour l'essentiel dans le cadre de la lutte contre les changements climatiques dus au réchauffement global. Il s'agit entre autres : de l'adaptation variétale, de l'usage des techniques de conservation des eaux et des sols, de l'amélioration de la fertilité des terres par apport de fumure organique, etc.

Des innovations importantes ont aussi été apportées par les éleveurs nomades à leurs pratiques, afin de s'adapter à la variabilité climatique qui est une contrainte naturelle intégrée comme une condition intrinsèque de la production, mais dont l'intensité s'est accrue.

Ces innovations s'articulent autour de la mobilité, principale stratégie, et concernent : rationnement qui consiste à modifier foncièrement les rôles et responsabilités en matière de gestion des greniers, l'usage de plantes de substitution pour compenser le déficit vivrier, le stockage de nourriture qui, chez les éleveurs passe par l'accumulation de bêtes sur pied, la dispersion des troupeaux qui prend souvent la forme de prêt de bétail, la diversification des espèces animales élevées pour utiliser au mieux les ressources de l'environnement mais aussi et la diversification des activités de production. La maîtrise des cycles de gestation des animaux qui traduit une profonde connaissance par les pasteurs, de l'activité et de leurs bêtes est également mise à contribution.

Mais ces pratiques et techniques qui ont été plus ou moins efficaces pour survivre aux sécheresses suffiront-elles face aux changements climatiques dont l'ampleur et l'intensité risque de se décupler ? Si ces pratiques agricoles et pastorales semblent plus ou moins éprouvées pour ce qui concerne la variabilité, quelles seraient les limites de ces réponses locales à des changements plus structurelles du climat, surtout aux niveaux thermique et pluviométrique et sur un long terme ? Comment analyser les expériences locales de lutte contre la sécheresse et tirer le meilleur profit des leçons apprises pour

une adaptation durable qui interpelle, au-delà des communautés, les Etats et leurs partenaires internes et extérieurs.

Introduction

Les commentaires du Secrétaire Général des Nations Unies, M. Ban Ki-Moon, sur la sécheresse survenue dans la Corne de l'Afrique en 2011, semblent résumer le contexte global d'occurrence des changements climatiques. Il disait ceci : «la sécheresse actuelle est encore probablement la pire depuis des décennies, mais les effets du changement climatique se faisant de plus en plus sentir partout dans le monde, elle ne sera certainement pas la dernière ».

Le Groupe d'experts intergouvernemental sur l'évolution du climat (GIEC), place en effet, le Sahel et l'Afrique de l'Ouest parmi les régions les plus vulnérables aux changements climatiques futurs ; ils pensent même qu'ils pourraient faire obstacle à la réalisation des objectifs de développement.

En réalité, le changement climatique en tant que tel n'est pas un phénomène nouveau. Il est reconnu que cette région de l'Afrique, a connu différents épisodes de sécheresses[4]. En effet, les traditions recueillies par les anthropologues et confirmées par les recherches menées par les géomorphologues, hydrologues, palynologues et botanistes, attestent que le Sahel aurait connu l'irrégularité des pluies depuis toujours et que les sécheresses de 1909-1913[5], 1940-1944, 1969-1974, et 1983-1985 ont été enregistrées partout ; la dernière ayant permis de noter des minima pluviométriques absolus (Bernus et al, 1993).

Il s'agit essentiellement du déficit pluviométrique, de la forte variabilité interannuelle des précipitations, des perturbations sensibles dans l'arrivée et la fin des saisons pluvieuses et de l'occurrence d'extrêmes climatiques[6].

Les manifestations du changement climatique dont les experts prévoient l'intensification dans le futur, sont dans une large mesure, identiques à celles des sécheresses que ces communautés ont vécues et marquées par une très forte variabilité pluviométrique. Cependant, celles-ci vont se combiner à une hausse constante des températures qui pourraient avoir un impact considérable non seulement sur les rares précipitations qui vont tomber et sur l'assèchement et la dégradation des terres, mais aussi sur la santé humaine et animale.

En effet, il semble que les zones sahélo-sahariennes, sahéliennes et soudaniennes aient connu des augmentations de températures de l'ordre de 0,2°C à 0,8°C par décennie depuis la fin des années 1970s (CEDEAO-CSAO/OCDE, CILSS, 2008) ; Toujours selon, le CSAO-OCDE, cette hausse de la température moyenne entre 1980/99 et 2080/99 pourrait atteindre entre

3 et 4°C sur l'ensemble du continent, soit 1,5 fois plus qu'au niveau mondial.

Les années 1970 (particulièrement 1972 et 1973) et 1980, restent gravées dans la mémoire collective en raison de la misère consécutive à ces sécheresses répétitives. Derrick (1977), fait en effet

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[4] C'est celle de 1972-1973 qui a fait couler le plus d'encre, pour avoir été très dévastatrice. Cependant, le Sahel a connu d'autres périodes de sécheresse entre les années 1909 et 1914 et 1940 et 1946.

[5] Les dates de ces sécheresses peuvent varier d'un auteur à un autre, confirmant ainsi la disparité qui peut exister au plan spatial. Pour certaines périodes en effet, l'assèchement observé est généralisé alors que pour d'autres, il est plus localisé.

[6] Avec le réchauffement actuel des températures, les extrêmes climatiques ne se limitent plus aux sécheresses mais alternent avec les inondations, rendant encore plus complexe l'adaptation.

remarquer que les précipitations dans l'ensemble de la ceinture que constitue la savane de l'Afrique de l'ouest, étaient largement en dessous de la normale. Dans un contexte où les populations dépendent pour leur survie, de l'agriculture et de l'élevage, principaux moyens de subsistance qui ont été gravement affectés par la baisse des pluies, cette sécheresse a été un véritable drame pour des millions de personnes qui n'avaient pas d'autres ressources pour survivre.

Comment les communautés sahéliennes ont elles survécu à la sécheresse ? Quelles stratégies ont été mises en place pour s'adapter aux conséquences de la sécheresse qui étaient à la fois multiformes et complexes parce que se combinant avec d'autres facteurs moins en lien avec le climat ?

Selon Mertz, Mbow, et al. (2010), il apparaît clairement que des réponses adéquates ciblées face aux changements climatiques à venir, exigent de comprendre un peu mieux l'impact du climat sur les changements d'affectation des terres et sur les moyens de subsistance, comparé aux autres facteurs.

Dès lors, il importe de diffuser les connaissances acquises et les leçons retenues des périodes de stress climatique passées, et qui constituent des points d'entrée essentiels pour un apprentissage collectif et des stratégies d'adaptation plus robustes face aux changements futurs.

A titre d'exemple, Kandji et al. (2006), s'appuyant sur un scénario pour le Sénégal, qui prévoit une baisse de la pluviométrie de 20% et une hausse de la température de 4°C, sur la base des données de 1961-1990, font état d'une réduction potentielle de la production de mil, de 33 à 25%, en plus de celle des terres favorables à cette culture. Cette même baisse était respectivement de 79 et 63% durant les sécheresses de 1972 et 1973. Y-aurait-il là, des leçons à tirer en termes d'intensification de la production et d'amélioration des conditions de la productivité?

La question principale qui est posée ici, c'est : face à des tendances de changement climatique similaires, comment apprendre des périodes de sécheresse passées pour améliorer les stratégies d'adaptation mises en place par les communautés locales, afin de renforcer leur résilience face aux changements futurs ?

Pour cela, il est utile d'analyser i) l'impact que les sécheresses récurrentes des années 1970 et 1980, ont eu sur les activités agricoles et pastorales principalement, ainsi que sur les moyens de subsistance des populations de l'est du Sénégal et du Sahel ; ii) les réponses locales apportées et iii) la manière dont les expériences de lutte contre la sécheresse pourraient être capitalisées.

Les exemples pour illustrer les impacts ou réponses face aux sécheresses, sont parfois choisis dans d'autres pays de la sous-région qui partagent les mêmes caractéristiques de pays sahéliens.

La sécheresse et ses conséquences sur les activités et les moyens de subsistance des communautés

La sécheresse dans le Sahel a trouvé son illustration la plus répandue dans le drame vécu par les pasteurs nomades peul et touareg, bien qu'elle ait affligé tout aussi sévèrement les paysans sédentaires (Santoir, 1976).

La dernière sécheresse n'est que l'épilogue d'une série de mauvaises années qui se sont succédées depuis 1968 et qui ont abouti à un assèchement progressif de la région sahélienne (y compris la zone d'étude) aux conséquences dramatiques.

Dans tous les pays concernés, l'agriculture et l'élevage représentent non seulement les activités principales des populations, mais aussi les locomotives des économies nationales, employant généralement plus de la moitié de la population et contribuant à hauteur de 40 % voire plus, à la formation du PIB (CILSS 2004, cité par Kandji et al., 2006). La chute vertigineuse de la production agricole, toutes spéculations confondues et la forte mortalité des animaux, consécutive au manque

d'eau et de pâturages, ont eu des implications économiques considérables tant au niveau macroéconomique que des ménages. La dégradation des ressources en eau et des sols, aggravée par la déforestation et la désertification ainsi que l'anéantissement des troupeaux, ont provoqué ou aggravé la faim et la malnutrition, et plongé les communautés dans une misère totale.

L'agriculture était en total déclin. En effet, les famines et les disettes, laissant la place à d'autres catastrophes plus ou moins liées au climat telles que les invasions de criquets, d'oiseaux mange-mil ou d'insectes, au moindre retour des pluies, étaient devenues récurrentes.

C'est pourtant l'élevage et les pasteurs qui ont payé le plus lourd tribut ; Santoir (1976) explique cela par le fait que l'impact de la sécheresse a été particulièrement sensible sur le milieu végétal. Il explique que dans le "diéri", la strate herbacée, composée pourtant d'espèces annuelles peu exigeantes en eau, n'a pu se reconstituer, le plus fort apport mensuel de pluie dépassant à peine 30 mm. Il conclut que lors de l'hivernage 1972, l'efficacité des rares pluies, fut nulle et le tapis herbacé absent, aucune germination ayant eu lieu.

Il s'y ajoute que dans le cas de l'agriculture, les champs étant fixes, une amélioration des conditions pluviométriques d'une année à l'autre est toujours profitable ; par contre avant l'arrivée de ces pluies, la soif et l'absence de nourriture ont déjà décimé une bonne partie du bétail.

Les sécheresses des années 1970 et 1980, combinées à d'autres causes non climatiques comme la pression démographique, les technologies et/ou les politiques inadaptées, ont également induit une forte mobilité qui a pris la forme d'une migration définitive pour certains.

En effet, la dégradation sensible des conditions de vie des ruraux est aujourd'hui considérée, à tort ou raison, comme l'une des causes majeures de la surpopulation et du sous-emploi chronique dans les agglomérations urbaines, suite à l'exode massif qui a suivi ces différents épisodes de sécheresse. Et il est intéressant de noter avec Santoir, que le groupe peul est celui qui envoie le moins de migrants vers les villes. Si la mobilité est un trait essentiel de leur mode de vie, elle se traduit rarement en départ définitif.

En outre, il fait remarquer, que la caractéristique principale des Peul "diéri" avant la sécheresse, à savoir la fixation importante, semble avoir été le facteur d'inertie, responsable des plus grosses pertes en bétail. La mobilité a donc été, assurément, un des éléments structurants de la capacité de réaction de l'élevage nomade face à la sécheresse.

Pourtant, la tendance, avec les politiques modernes d'élevage, est surtout à la sédentarisation de l'élevage nomade dont la principale motivation semble être le besoin de modernisation de l'activité considérée encore comme archaïque et contemplative. Touré (1987) confirme cette option de l'Etat dont les interventions et actions de développement entreprises ces dernières années ont eu pour conséquences directes de modifier le mode de vie des pasteurs avec l'apparition des forages qui contribuent à la fixation des éleveurs.

Les réponses locales face aux sécheresses et à leurs impacts

Les réponses fournies par les communautés sahéliennes face à la variabilité climatique ont été variées.

Les réactions qui nous intéressent ici, concernent exclusivement l'agriculture et l'élevage qui non seulement constituent les principaux moyens d'existence des populations mais sont également parmi les secteurs les plus vulnérables aux changements de climat.

De manière générale, les populations ont élaboré et utilisé une gamme variée de stratégies allant de la diversification des cultures, la cueillette de feuilles et fruits sauvages, le petit élevage, à l'exercice de petit commerce et d'autres petits métiers. La mobilité ou migration est aussi partie intégrante des

stratégies utilisées face à la dégradation des revenus tirés de l'activité agricole et consécutive aux sécheresses récurrentes.

Parties de réactions spontanées et autonomes, les techniques et pratiques utilisées dans le domaine agricole, ont souvent fait l'objet d'une amélioration notable, grâce à la recherche scientifique et aux innovations technologiques. Elles semblent avoir produit des résultats intéressants au point d'être reconduites pour l'essentiel dans le cadre de la lutte contre les changements climatiques dus au réchauffement global.

Ces techniques concernent généralement le changement de type de cultures et de variétés, une meilleure gestion des terres, la modification des techniques agricoles et l'amélioration des techniques de gestion de l'eau (Ouédraogo et al, 2010). De manière plus spécifique, on peut citer : l'adaptation variétale, l'usage des techniques de conservation des eaux et des sols (aménagements de diguettes, de cordons pierreux, demi-lunes), l'apport de fumure organique, (la technique zaï est une des techniques qui s'appuie beaucoup sur cet apport de fumure organique), le déplacement des zones de culture (emblavement des bas-fonds par exemple, pour mieux tirer profit de l'humidité du sol).

La reconversion à d'autres métiers comme l'artisanat, le petit commerce, le gardiennage, la forge, etc., constituait une autre alternative au déclin de l'agriculture.

L'émigration a été également un des principaux moyens de survie des communautés face aux sécheresses récurrentes. Les périodes de sécheresses prolongées sont d'évidence des moments et des contextes d'accélération et d'amplification de la pauvreté des populations ; elles ont généré de graves crises alimentaires et la famine qui ont été dans de nombreux cas, les déclencheurs d'une émigration massive et incontrôlée des paysans pauvres, d'abord vers des centres urbains puis vers d'autres pays africains et européens.

Copans (1975) explique comment la gravité des sécheresses des années 1970 et 1980 a totalement bouleversé les règles de fonctionnement des communautés du Plateau mossi, y compris celles qui régissaient l'émigration commencée des décennies auparavant[7]. Par exemple, deux enfants d'une même famille ne pouvaient pas se retrouver simultanément en Côte d'Ivoire ; il fallait que l'un revienne pour que l'autre puisse partir. Mais les effets désastreux de la sécheresse ont poussé les jeunes gens, déboussolés, à ne plus respecter ces alternances de départs et de séjours. La conséquence majeure a été le manque de bras pour épauler la génération ascendante d'agriculteurs afin de tirer le strict minimum de la terre.

La région Est du Sénégal concernée par la présente étude (mais aussi d'autres régions sahéliennes), est de ce point de vue, une des principales zones de départ pour la migration interne ou internationale. Le plateau mossi au Burkina Faso est également connu pour être une zone d'alimentation par excellence de l'émigration.

Cette migration est aujourd'hui motivée par diverses raisons y compris politiques et économiques, mais les catastrophes environnementales et notamment climatiques, ont indéniablement alimenté les premiers départs massifs enregistrés.

Les innovations que les éleveurs sont amenés à mettre en œuvre pour s'adapter aux conditions climatiques changeantes et notamment à la forte variabilité de la pluviométrie, sont d'une richesse

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[7] La migration des paysans mossi notamment vers de la Cote d'Ivoire remonte d'avant les sécheresses de 1970 et 1980 mais ne serait pas étrangères à celles qui ont affecté le Sahel en de 1910 à 1916 et de 1940 à 1945.

égale voire supérieure à celles répertoriées en agriculture ; cependant, elles sont moins bien documentées.

Ce qu'il faut faire remarquer d'emblée, c'est que la variabilité climatique constitue, chez les éleveurs nomades, une contrainte naturelle qui est intégrée comme une condition intrinsèque de la production.

Pour faire face à cette contrainte qui peut aller d'un simple déficit pluviométrique à des sécheresses extrêmes et répétées comme dans les années 1970 et 1980, les éleveurs disposent dans leur système technique et leur organisation économique et sociale, de capacités de réponses efficaces (Bonte, in Copans, 1975).

Ces réponses s'articulent principalement autour de la mobilité. Bonte (op.cit.), dans son analyse de la réaction des pasteurs et nomades de Mauritanie, fait remarquer que la *capacité de déplacement rapide* constitue la première réponse et sans doute, la plus importante. Il rappelle que durant les années désastreuses, comme celles des années 1970, les éleveurs ont été amenés à se déplacer au loin sur de meilleurs pâturages. Cependant, les distances parcourues par ces éleveurs ne sont pas les mêmes ; on distingue notamment les grands nomades chameliers qui n'hésitent pas à accomplir plus de mille kilomètres pour trouver l'eau est les pâturages, alors que les transhumants ordinaires font entre cinquante et deux cents kilomètres.

Les observations faites par Swift (in Copans, 1975) à partir des Touaregs de l'Adrar des Iforas au Mali, corroborent la thèse de Bonte. La possibilité de se déplacer en fonction des circonstances, serait, selon lui, l'élément le plus évident de la stratégie nomade contre les incertitudes de la nature ; les déplacements, la meilleure protection contre une catastrophe[8]. Il note également que des formes de déplacement de longue distance avaient été institutionnalisées par un ensemble d'accords et d'alliances entre les grands groupes ethniques.

Il apparait donc clairement que les éleveurs sahéliens quel que soit le pays considéré, ont eu en commun cette stratégie séculaire d'adaptation qu'ils ont combinée avec d'autres options plus diversifiées et dictées par les contraintes et les ressources du milieu.

Copans (1975) relate des pratiques comme *le rationnement* qui consiste à modifier foncièrement les rôles et responsabilités en matière de gestion des greniers. Donnant l'exemple des communautés du plateau mossi en Haute Volta, il remarque que "si en temps normal, ce sont les femmes et les épouses qui prélèvent plusieurs fois par semaine, les quantités nécessaires à la préparation des repas, le chef de l'enclos ou du foyer familial ne laisse à personne d'autre le soin de mesurer, jour après jour, le grain devenu rare ". Cette forte baisse des rations alimentaires est souvent compensée par un *usage de plantes de substitution* (herbes, feuilles, graminées), la cueillette contribuant sensiblement à procurer ce que l'agriculture n'a pu fournir.

Cette forme d'adaptation a des implications en matière de genre, mettant en lumière des changements significatifs dans l'organisation sociale du travail et notamment les rôles des hommes et des femmes ; en effet, les femmes avaient coutume, en temps normal, d'assumer seules la recherche de plantes comestibles qui venaient en complément aux céréales. En période de pénurie extrême, les hommes qui trouvent cette tâche dégradante, sont contraints de se joindre à elles pour récolter le maximum de produits ; ils s'occupent alors de couper les branches que les épouses et enfants dépouillent de leurs feuilles.

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[8] Par analogie, on considère généralement que les populations urbaines qui, en période d'inondation, ont la possibilité de quitter le domicile pour en rejoindre un autre (domicile de parents ou de relations autres), sont moins vulnérables que ceux qui n'ont d'autres choix que de rester.

Toujours à propos des Touaregs, Swift évoque une gamme de stratégies fondées sur la *souplesse* et la *flexibilité* qui sont les caractéristiques majeures de l'adaptation dans le secteur de l'élevage. On peut retenir parmi ces stratégies :

Le stockage de nourriture

Cette option, qui est courante chez les agriculteurs qui tirent profit des surplus de récoltes enregistrés durant les années favorables, est bien plus difficile chez les éleveurs dont les produits se conservent au plus quelques mois (par exemple le fromage fabriqué à partir du lait). Le stockage se fait alors sous forme d'animaux vivants, en accumulant si possible des troupeaux qui excèdent leurs besoins de subsistance, afin de pouvoir les vendre ou les échanger contre des céréales lorsqu'ils sont dans le besoin. Une telle accumulation, attribuée parfois faussement à un désir irrationnel de posséder des animaux de prestige, est en fait un élément central de la stratégie contre les incertitudes naturelles (Swift, in Copans, 1975).

Wane et al (2010) confirment la thèse de Swift, en démontrant que les pasteurs ne sont pas seulement des êtres contemplatifs de leurs troupeaux mais sont aussi insérés dans le marché notamment par la commercialisation d'animaux de rente. Cependant, les divers types de bétail qu'ils possèdent, sont en réalité, une forme de capital, de trésorerie ou d'assurance tous risques (risques liés au marché, mais aussi risques climatiques).

La dispersion des troupeaux

Le bétail sur lequel un producteur a des droits, n'est jamais rassemblé autour de lui ou concentré en un endroit. Il est dispersé dans d'autres campements ; des bêtes sont prêtées pour le lait, d'autres sont données sous-réserve de réciprocité à des parents. Cette stratégie rejoint quelque part le concept de *partage des animaux* qui consiste pour les riches éleveurs en la possibilité de posséder plusieurs milliers de têtes de bétail, sans grossir exagérément leur propre unité de production, avec les risques que cela comporte (Bonte, 1975). Ce système prend souvent la forme de *prêt de bétail* comme en Mauritanie où il porte le nom de *menina* et a pour particularité de se produire entre un riche et un pauvre.

La diversification des troupeaux et des activités de production.

Elle facilite l'adaptation aux situations difficiles. Il s'agit là, non seulement de diversification des espèces élevées (bovins, ovins, caprins, et camélidés), mais aussi de l'exercice d'autres métiers en complémentarité de l'élevage. C'est dans ce cadre que se pratique de manière accessoire l'agriculture dans les zones où cela est possible (par exemple dans les oasis en Mauritanie, ou dans la zone du Walo, pour les villages du diéri qui sont les plus proches du fleuve Sénégal). En somme cette diversité donne une grande flexibilité au système et permet d'utiliser toutes les ressources de l'environnement. Bonte (in :Copans,1975) note aussi, outre le *métier gardien* de troupeaux qui s'est développé après que certains éleveurs ont perdu une bonne partie de leur bétail, *les razzia et pillages de bétail* qui ont joué un rôle non négligeable en favorisant la redistribution du bétail entre les zones dévastées et celles épargnées par des catastrophes naturelles. Cette forme de "maladaptation" pourrait être assimilée aux vols de bétail auxquels l'on assiste en ce moment et qui provoquent des conflits parfois sanglants.

La maîtrise de la biologie des animaux

Swift (in : Copans, 1975), mentionne au-delà de ces stratégies, une profonde connaissance de l'activité et de leurs bêtes par les pasteurs, connaissance qui renforce la flexibilité évoquée plus haut et qui permet de jouer sur les ressources disponibles. Il fait remarquer en effet, que les différents animaux qui composent le troupeau, n'ont pas les mêmes exigences en matière de surveillance, d'abreuvement ou de traite. Les moutons par exemple, exigent beaucoup de travail et doivent être constamment

surveillés, à la différence des chameaux ou des bovins souvent laissés sans gardiens et qui peuvent divaguer pour trouver de manière opportuniste des ressources à consommer.

Même *les cycles de gestation des espèces* qui est très liée à l'environnement et notamment la pluie, est mise à contribution dans le choix des espèces à privilégier en période critique comme les sécheresses. En effet, il ressort que les cycles de gestation sont différents chez les bovins, les ovins ou les camélidés. Les vaches et les chamelles dont la gestation dure respectivement dix et douze mois, ne conçoivent qu'après les premières pluies et la reconstitution des pâturages ; de sorte que leurs petits naissent tôt dans la saison des pluies suivante, lorsque les pâturages sont les plus riches. Par contre, on ne laisse pas les moutons s'accoupler avant décembre ou janvier, afin que les agneaux naissent également durant la saison des pluies. Les chèvres quant à elles, constituent le meilleur recours en cas de détresse, du fait de la faible durée de leur gestation et de leur robustesse. Le décalage de ces naissances, permet d'utiliser de manière optimale les pâturages de la saison des pluies (Swift in :Copans, 1975).

Il semble donc qu'il y ait eu au niveau de la communauté pastorale, un ensemble de traits de l'organisation économique et sociale mais aussi des connaissances endogènes solides qui aient servi de socle aux stratégies d'adaptation aux sécheresses récurrentes.

Un certain nombre de questions découlent alors de cette analyse ; parmi lesquelles : (i) comment ces pratiques historiques informent-elles les stratégies mises en œuvre dans le cadre des changements climatiques ? (ii) Les dérèglements climatiques issus du réchauffement global dû à des causes anthropogéniques présentent-ils en tous points, les mêmes caractéristiques pour qu'une simple transposition des stratégies déployées face à la sécheresse soit suffisante face aux impacts des changements climatiques ; ou présentent-ils des spécificités qui exigent d'autres types et formes de réponses ? (iii) Enfin, les politiques ou initiatives d'adaptation planifiée, autrement dit, les interventions extérieures, qu'elles émanent de l'Etat ou d'autres partenaires, peuvent-ils être des leviers pour renforcer les stratégies locales positives et non les entraver?

Sécheresses et Changements climatiques : quelles leçons pour quelles perspectives ?

Il est clair que les stratégies de lutte contre les changements climatiques, mises en œuvre dans le domaine climatique, s'inspirent largement des pratiques et techniques expérimentées par les communautés locales durant les sécheresses. En effet, les techniques de conservation de l'eau et des sols (micro-diguettes, cordons pierreux, demi-lunes ou de gestion intégrée de la fertilité des sols (zaï, parcage des bêtes, contrats de fumure, etc.) pratiquées dans la plupart des pays sahéliens, trouvent sinon leur origine, du moins leur développement et/ou leur extension et leur intégration dans les systèmes modernes de production agricole, dans la sécheresse qui a frappé la plupart des pays. Quel qu'ait pu être l'apport de ces techniques et pratiques, il sera pourtant indispensable de procéder à leur évaluation, en tenant compte des caractères intrinsèques des changements climatiques. Ces caractères relèvent essentiellement de deux hypothèses : la première est basée sur la tendance à l'aridification du Sahel et à des sécheresses encore plus sévères que celles vécues par les populations sahéliennes. La question devient donc : les pratiques et techniques utilisées pour faire face suffiront-elles, surtout dans un contexte de croissance exponentielle de la population et donc d'augmentation de bouches à nourrir ? Quelle marge de progrès existe dans le cadre de ces techniques pour qu'elles arrivent à garantir les niveaux de production capables de soutenir une sécurité alimentaire durable ? Quelles sont les contraintes à lever pour véritablement promouvoir ces techniques et permettre leur accessibilité surtout aux couches les plus vulnérables ? Par exemple, comment l'accès au foncier, au crédit et aux semences de bonne qualité, entre autres, peut-il être un frein à l'adoption de telles pratiques et quelles politiques pour lever ces obstacles ? La deuxième hypothèse est relative à l'alternance entre les phénomènes extrêmes que sont les sécheresses, et les inondations dont la fréquence s'est accrue ces dernières années. Comment les populations locales pourraient-elles faire

face d'une année à l'autre à ce type de catastrophes qui exigent des réponses totalement différentes? Si elles sont plus ou moins préparées aux sécheresses, cela n'est pas nécessairement le cas avec les inondations. Sont-elles en mesure de gérer seules, cette incertitude et les risques associés ? Comment les appuyer dans cette gestion ? A partir de quelles connaissances et expériences ?

Si l'on considère le domaine de l'élevage, l'adaptation à la variabilité climatique semble être une donne permanente ; en effet, l'activité pastorale et les stratégies mises en œuvre par les pasteurs pour survivre avec leurs troupeaux, sont intrinsèquement liées à la gestion de l'incertitude et de la rareté ; rareté des pluies, rareté des pâturages.

Les réponses apportées par les pasteurs pour gérer cette incertitude et cette rareté reposent essentiellement sur la mobilité et la flexibilité des modes d'exploitation des ressources de l'environnement. Or il semble de plus en plus que ce sont ces deux paramètres (mobilité et flexibilité) que les programmes de développement risquent de remettre en cause, consciemment ou inconsciemment. De ce point de vue, il est urgent de mieux prendre en compte dans l'évaluation de la vulnérabilité et de l'adaptation, non seulement les facteurs non climatiques (facteurs politiques, vulnérabilité institutionnelle, économique, etc.) et la manière dont ils contribuent ou non à renforcer la vulnérabilité des populations. Il est tout aussi urgent de mieux analyser les implications de ce qu'il est convenu d'appeler "modernisation de l'élevage " et dont l'un des leviers principaux et la mise en place de forages autour desquels les populations pastorales et leurs troupeaux ont tendance à se sédentariser, avec les avantages que cela procure bien sûr, mais aussi les impacts négatifs (pression sur les ressources fourragères, érosion du capital financier, dégradation des terres, etc.).

De ce point de vue, les stratégies d'adaptation adoptées dans un secteur donné, peuvent renforcer la vulnérabilité dans l'autre. C'est le cas par exemple avec l'adoption de modes intensifs de production agricole qui amène à une privatisation des terres de cultures et à la mise en clôture pour les sécuriser. Ces clôtures obstruent souvent les couloirs d'accès aux points d'eau et provoquent des conflits entre agriculteurs et éleveurs, qui sont préjudiciables à un aménagement durable des espaces et des ressources et à l'intégration agro-sylvo-pastorale présentée pourtant comme l'une des solutions aux changements climatiques, à travers les possibilités qu'elle offre pour l'adaptation mais aussi pour l'atténuation.

Conclusion

L'une des particularités du changement climatique, c'est non seulement la variabilité mais également le changement à long terme du climat. Les pratiques des communautés agricoles et pastorales semblent plus ou moins éprouvées pour ce qui concerne la variabilité, les sécheresses climatiques qu'a connues le Sahel étant plus caractérisées par une extrême irrégularité que comme une tendance régulière à un assèchement. Il est donc nécessaire de comprendre quelles seraient les limites des réponses locales apportées à des changements plus radicaux mais surtout plus durables, à la lumière des expériences et des leçons tirées de la période antérieure. Pour ce faire, des études ciblées seront indispensables et devront mettre un accent particulier sur les perceptions des populations, en particulier des éleveurs dont les points de vue sont rarement pris en compte. Une meilleure compréhension du système global mais aussi des forces et faiblesses intrinsèques au sein des sous-systèmes (agriculture et élevage notamment), serait la meilleure garantie d'une intervention extérieure, par l'Etat ou les partenaires.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEX I

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ARCC

African and Latin American Resilience to Climate Change Project

ANNEX I. POTENTIAL CLIMATE CHANGE IMPACTS ON THE PRODUCTIVITY OF SELECT AGRICULTURAL CROPS IN THE ARCC SENEGAL VULNERABILITY ASSESSMENT STUDY ZONE: A BASELINE ANALYSIS

1.0 INTRODUCTION

This study reviews existing literature on the agronomy and phenology of the principal crops grown in the study zone of eastern Senegal, and summarizes the relevant characteristics of each crop to produce a rough overview of the crop's climatic production parameters by phenological stage. It then uses a rough characterization of future climate, based on annual average temperature and precipitation, to derive potential impacts of climate change on the productivity of those crops. We recognize that a wide range of factors in addition to mean annual temperature and rainfall affect the productivity of crops. These include soil characteristics; the intra-seasonal distribution of rainfall and temperature; farmer management practices; and seed variety. Nevertheless, in this assessment we propose that the characteristics of different crops are sufficiently distinct that this method can be used to establish the relative vulnerability of the various principal crops grown in the study zone.

To estimate impact, the profiles are based on worst-case assumptions concerning future climatic conditions by 2100. For the departments of Matam and Kanel, we assume a mean increase of 2.35 °C in the minimum normal temperature and a 2.0 °C increase of the maximum temperature. In Goudiry and Bakel, we assume a mean increase in the minimum normal temperature of 2.2 °C and a 1.9 °C increase in the maximum temperature. Regarding annual rainfall, we assume a decrease to 424 mm (-16 percent) in the north, and a decrease to 631 mm (-11 percent) in the south.

The document also explores, for each crop, the potential impact of increasing temperature and decreasing rainfall on the pests and diseases that afflict them.

This study takes a phenological perspective to present possible changes in crop development and pest and disease incidence resulting from posited changes in climate in eastern Senegal. Current climate models consistently project an increase in temperature at all times during the growing season in the study zone. Regarding rainfall, they project a wide range of changes, increases as well as decreases. [1] For the purposes of this study, we posit a significant decline in rainfall.

Most of the crops in this study are well adapted to the high temperatures and low rainfall of their current climatic conditions. Millets, cowpea, and sorghum are known to be resilient and have good levels of drought tolerance. Sweet potatoes are also quite tolerant, but are restricted to the southern regions of Senegal where water levels are higher. Groundnut cultivation continues to spread across Senegal, both because this crop "wears out" the soils in which it is cultivated, and because it is the country's most important cash crop (Adigbli, 2009; Elberling et al., 2003). This study finds that drier-hotter conditions in Senegal will limit the areas for further expansion. The combination of heat and drought in parts of Senegal has proven to affect the crop quite seriously (Boyer, 1982; Chen et al., 2012). Climate change is likely to aggravate this condition in the southern areas of the study zone where it is currently grown.

As a proxy for the little-studied forage and grasses of the study zone, we examined pasture species of the Ferlo region, about which more information is available. These native forages and grasses are also adapted to current conditions. Ferlo is a forestry-pasture zone with little human input and significant

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[1] The climate data used was drawn from historical climate records for Senegal and climate models generated in general by the NCAR Community Climate Model (CCM3)[1] (Govindasamy et al., 2003; Kiehl et al., 1996; Lawrence and Chase, 2010).

rainfall contrasts between northern and southern regions. It is possible that climate changes will trigger changes in vegetation structure that will in turn result in pest infestations that alter species balance and population density and create new dominance levels. However, there is very little information in the literature reporting changes in forage and grass species balance in this region.

The crops under study are well-adapted to the high temperatures and low rainfall of the regions of Senegal under study, and, consequently, levels of natural resilience are very high. However, most reports indicate that future climate changes will make these regions even drier and warmer (Christensen et al., 2007). So, although crops are adapted to the present conditions of the Sahel, changes in climatic conditions will impact crop productivity in the future and, in the extreme, can make some areas unsuitable for plant cultivation. For all of these plants, crops as well as forage and grasses, the impact of the projected climatic changes would be significant at all stages of plant development, and most significant at germination and early emergence, the stages during which plants are most vulnerable. If, contrary to our assumption, rainfall increases, such a change could enhance germination and emergence stages and positively affect yields across the study zone. On the other hand, an increase in temperature and drop in rainfall would likely result in damage at these stages and weaken the plant irreversibly, thus reducing the plant's ability to achieve maximum yield and crop quality. Given our assumptions, the major conclusion of this study is that there is marginal potential for agriculture in the study zone by 2100.

Assumptions and Weaknesses of the Methodology

This study has generated information on the potential impacts of changes in climate conditions on different phenological stages of select crops grown in the study zone. This report also describes the pests and diseases observed affecting these crops and evaluates how climate can influence the occurrence of these pests and diseases.

Based on climatic data, we divided the analysis into two regions: 1) Matam and Kanel, and 2) Goudery and Bakel. The region consisting of the two more northern departments of Matam and Kanel receive less rainfall than that containing the two southern departments of Goudery and Bakel. The CCM3 climate model (Govindasamy et al., 2003; Kiehl et al., 1996) was used to make the assumptions used for climate in each set of regions. For the departments of Matam and Kanel, the determinations of impact on crops, pests and diseases are based on a mean increase of 2.35 °C in the minimum normal temperature and a 2.0 °C increase of the maximum temperature by the year 2100. In Goudery and Bakel, the determinations of impact on crops, pests and diseases are based on a mean increase in the minimum normal temperature of 2.2 °C and a 1.9 °C increase in the maximum temperature by the year 2100. GCM models produce a wide range of results in terms of annual rainfall and seasonal change for Senegal. The yearly average rainfall is currently 506 mm for Matam and Kanel. For this study we assume a worst case scenario, with a decrease to 424 mm (-16 percent). Average annual rainfall is currently 710 mm for Goudery and Bakel. As with the northern departments, for this study we assume a decrease of rainfall to 631 mm (-11 percent).

This study concentrated on identifying only pests and diseases reported to occur in these regions of Senegal for the crops assessed. Since the geographic scope was reduced, we found that there was limited literature and scarce information. It appears that not many studies have been conducted in these regions in general. To overcome this lack of information, this study complemented the findings with information reported elsewhere and outside the target regions. This additional bibliography offered specific aspects needed to complete the reports. This information was related to the biology of the pest and diseases, such as information on life cycles, which helped to understand their occurrence and behavior. For example, once the pests and diseases were identified, we looked for further details on their modes of infestation-infection, ranges of survival, interactions with climate, etc. The same approach was taken to changes in climate and the ability of the pests and diseases to develop under given climatic

conditions. The additional sources we reviewed included scientific publications, books, reports, websites, etc.

A problem observed in searching for literature was the lack of consistency in some of the published work. In some cases the information was contradictory. For example, in a few cases we found that a given disease was indicated to prosper in warmer conditions, while other publications indicated the opposite, claiming that the disease actually develops better in cooler conditions. Whether we discovered such a contradiction or not, in all cases every piece of information used was corroborated by reviewing several sources. In all cases we considered the review of multiple sources to be mandatory; this helped us to determine which information was accurate.

Information on some of the crops was also lacking. In particular, fonio did not have significant sources of information. The same was found regarding forage and grass species.

Finally, and most important, the conclusions on the impacts are relative to vulnerability to climate change within optimal growth ranges; the indicators of impact are extrapolated from existing literature and do not necessarily obtain a high level of confidence.

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2.0 SORGHUM

Brief overview of the crop

Sorghum is Africa's contribution to the world's top crops, and belongs to the elite handful of plants that collectively provide more than 85 percent of all human energy. Today, it is the dietary staple of more than 500 million people in more than 30 countries. Only rice, wheat, maize, and potatoes surpass it in their contribution to feeding the human race (Smith et al., 2000). Grain sorghum is a grass similar to maize in its vegetative appearance, but sorghum has more tillers and more finely branched roots than corn (Doggett, 1988; Smith et al., 2000). However, the growth and development of sorghum is similar to corn, and other cereals. Sorghum seedlings are smaller than corn due to smaller seed size. Before the 1940s, most grain sorghums were 5-7 feet tall, which created harvesting problems. In present times, sorghums have either two or three dwarfing genes in them, and are 2-4 feet tall. While there are several grain sorghum groups, most current grain sorghum hybrids have been developed by crossing Milo with Kafir. Other groups include Hegari, Feterita, Durra, Shallu, and Kaoliang (Doggett, 1988). Sorghum head is a panicle, with spikelets set in pairs. It is mostly self-fertilized, but can also cross-pollinate. Sorghum flowers begin to open and pollinate soon after the panicle has completely emerged from the boot. Sorghum can branch from upper stalk nodes. If drought and heat damage the main panicle, branches can bear panicles and produce grain. The seed color is variable with yellow, white, brown, and mixed classes. Brown-seeded types are high in tannins, which lowers palatability.

Geographic distribution and general level of importance in the country

Sorghum is grown on 40 million ha in 105 countries in Africa, Asia, Oceania, and the Americas. The USA, India, Mexico, Nigeria, Sudan, and Ethiopia are the major producers. It is generally grown between 40 °N and 40 °S of the equator, in warm and hot countries characteristic of the semi-arid environment. But sorghum can be grown under a wide range of conditions and at altitudes of up to 2,300 m in the tropics. Sorghum and millet are very important cereals in the semi-arid areas of the tropics and subtropics of Africa. Generally, the area under cultivation of sorghum and millet in Africa has steadily increased over the years, but the average yield trends are downwards (Matlon and Adesina, 1991).

Life Cycle

The phenological stages in sorghum start at emergence when seedlings emerge from the soil. Before emergence, the plant is totally dependent on food reserves in the seed from the endosperm for survival. Slow-emerging plants risk depleting these reserves, which are important to early plant growth. Once sorghum emerges, the plant develops in a predictable manner characterized by three distinct growth stages. The first growth stage is characterized by vegetative growth. The plant develops its vegetative structures, leaves and tillers, which ultimately support grain formation and growth. The second growth stage includes a period when reproductive structures of the panicle form and the maximum number of seed per plant are set. This is the most critical period for grain production, because seed number per plant accounts for 70 percent of

sorghum's final grain yield. The third and final growth stage is grain filling which begins with flowering and continues until dry matter accumulation in the grain stops. In general, dry matter accumulation is complete at about 100 days after emergence (Quinby, 1974).

TEMPERATURE AND RAINFALL REQUIREMENTS OF SORGHUM AT DIFFERENT STAGES OF DEVELOPMENT

Sorghum	Seed Germination and Initiation	Emergence and Seedling Growth.	3-and 5-leaf Stages. Root Growth	Growing Point Differentiation and Floral initiation	Culm elongation, bloom stage and Soft-Dough Stage	Hard-Dough Stage and Physiological Maturity	Annual Average Optimal Temperature	Annual Average Optimal Rainfall	
Celsius	Temp	Temp	Temp	Temp	Temp	Temp	Temp		mm/year
37									1000
36									900
35									800
34									700
33									600
32									500
31									400
30									300
29									200
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Production parameters

Soil

Sorghum does well on most soils, but better in light to medium textured soils. The optimal soil conditions are well-aerated and well-drained. Sorghum is relatively tolerant to short periods of waterlogging. The fertilizer requirements are up to 180kg/ha N, 20 to 45 kg/ha P and 35 to 80 kg/ha K. Sorghum is moderately tolerant of soil salinity.

Water

The optimum growth requirements of sorghum plants include a medium to high, fairly stable rainfall pattern during the growing season. It is best adapted to areas with an average annual rainfall between 450 to 650 mm. Although sorghum responds well to good moisture levels, it is one of the most significant drought tolerant crops available, and this tends to increase its popularity in regions where the weather is very unpredictable. Sorghum tolerance to drought can be attributed to (a) an exceptionally well-developed root system, (b) small leaf area which limits transpiration, (c) leaves that fold up more efficiently during warm, dry conditions, (d) effective transpiration ratio, (e) corky epidermis and waxy layer that protects the plant from desiccation, (f) stomata that close rapidly, and (g) the ability to remain in a virtually dormant stage and resume growth when conditions are better.

Temperature

Sorghum is a temperate to warm weather crop (20-30 °C) and requires a frost-free period of approximately 120 to 140 days. The plant can tolerate high temperature throughout its life cycle better than any other crop. Sorghum requires temperatures of about 26-30 °C for good growth. The minimum temperature for the germination of the sorghum seed is 7 to 10 °C. Grain sorghum does not germinate and grow well under cool soil conditions. Poor emergence and seedling growth may result if planted before soil temperatures reach 35 °C.

Adaptability

Sorghum plants have diverse characteristics which make it a significant drought-tolerant crop. It is often grown under rainfed conditions which are suited for grain and forage production (Leuschner and Manthe, 1996). In dry areas with low and/or erratic rainfall, the crop can respond very positively to additional irrigation. However, significant differences are observed among varieties in their response to supplemental irrigation. Varieties and landraces which are considered very tolerant to drought only respond slightly, while others can produce high yields under irrigation but are poor yielding when water is limited.

Temperature is a critical factor in variety selection and cultivation. The optimum temperatures for high producing varieties are over 25 °C but some varieties are adapted to lower temperatures and produce acceptable yields. When average daily temperatures during the growing season are higher than 20 °C, early grain varieties take 90 to 110 days, and medium varieties 110 to 140 days to mature. When temperatures are below 20 °C, there is an extension of about 10 to 20 days in the growing period for each 0.5 °C decrease in temperature, depending on the variety, and at 15 °C a sorghum grain crop would take 250 to 300 days to mature. Similar to maize, if the daily temperatures are in the range of 10 to 15 °C, sorghum can only be grown as a forage crop because of the problems of insufficient seed set and poor grain maturity under cool conditions.

In addition, low temperatures (15 °C or lower) during flowering and yield formation, and high temperatures (>35 °C) lead to poor seed set, problems with ripening, and reduced yields

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3.0 COWPEA

Brief overview of the crop

Cowpea is considered a warm-season crop that has been grown in Senegal for centuries. Cowpea (*Vigna unguiculata* L.) is a member of the *Phaseoleae* tribe of the *Leguminosae* family. Members of the *Phaseoleae* include many of the economically important warm season grain and oilseed legumes, such as soybean, common bean, and mungbean. Cowpea is an annual crops grown for their leaves and seed. The growth habit is climbing, spreading, or erect. Cowpea is native to Africa, where it were domesticated over 4,000 years ago. The crop exhibits much variation in growth habit, leaf shape, flower color, and seed size. Cowpea is a food and animal feed crop grown in the semi-arid tropics. It originated and was domesticated in Southern Africa and was later moved to East and West Africa and Asia. The grains contain 25 percent protein, and several vitamins and minerals. The crop is adaptable to harsh environments, including extreme temperatures and water limiting conditions. The plant tolerates drought, performs well in a wide variety of soils, and, being a legume, helps replenish low-fertility soils. It is grown mainly by small-scale farmers in developing regions where it is often cultivated with other crops as it tolerates shade. More than 5.4 million tons of dried cowpeas are produced worldwide, with Africa producing nearly 5.2 million. Nigeria, the largest producer and consumer, accounts for 61 percent of production in Africa and 58 percent worldwide (Ng and Monti, 1990; Singh and Rachie, 1985)

Geographic distribution and general level of importance in the country

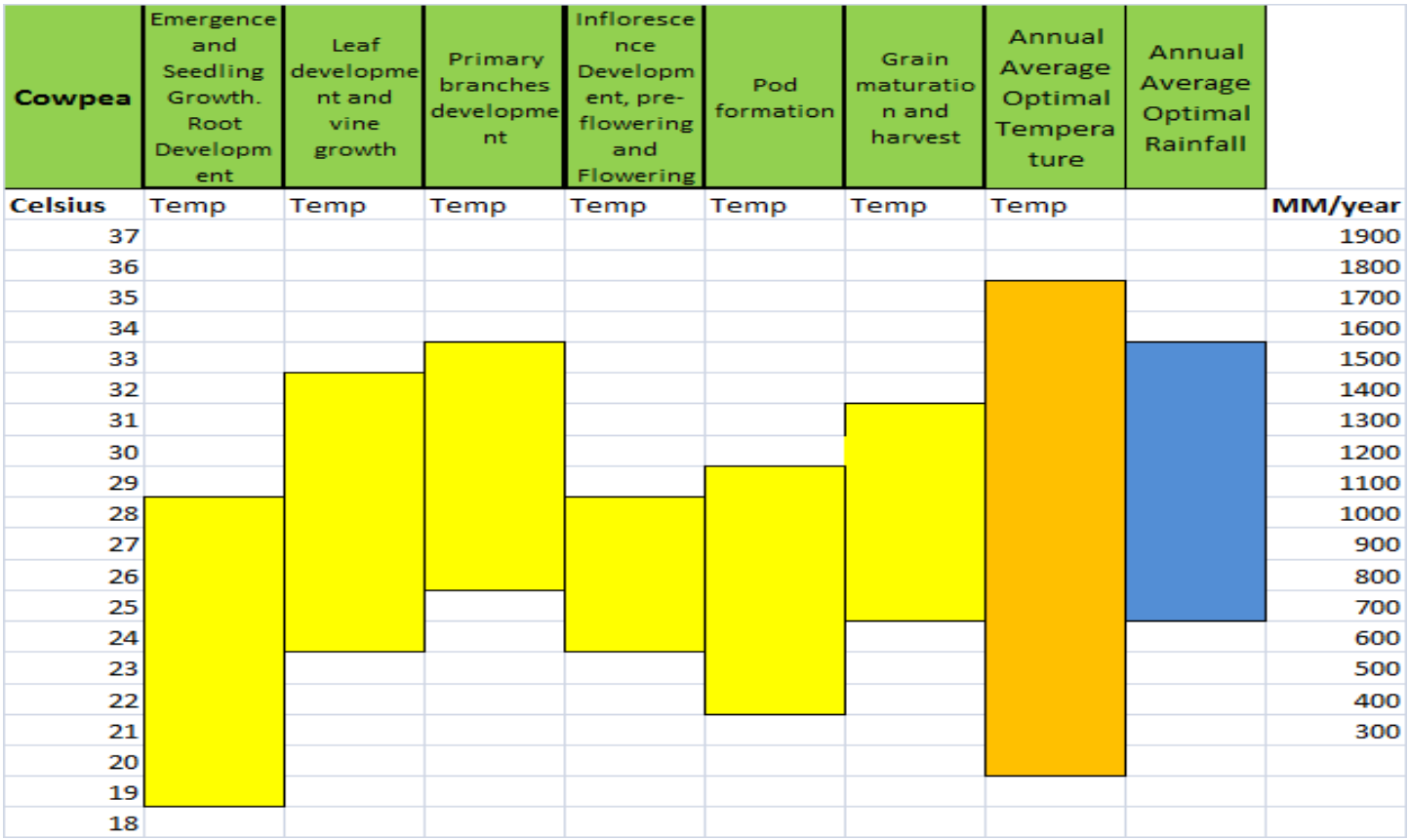
Cowpea has its origins in the same period as did ancient West African cereal farming: 5,000-6,000 years ago. It was closely associated with the domestication and cultivation of sorghum and pearl millet. It is now grown on a commercial scale in 33 countries in Asia, Africa, and Central and South America, as well as parts of southern Europe and the United States. Subsistence farmers in sub-Saharan Africa usually intercrop their cowpea with maize, sorghum, millet, and/or cassava. In rice farming, cowpea can be grown either before or after a crop to increase food production from a land area. In these systems, cowpea contributes by enriching the soil with nitrogen, helping to break the pest and disease cycle that occurs in continuous grain cropping, and is an additional source of farm income.

Life Cycle

Cowpea is an herbaceous warm-season annual that is similar in appearance to the common bean except that leaves are generally darker green, shinier, and less pubescent. Cowpeas also are generally more robust in appearance than common beans with better developed root systems and thicker stems and branches. Seedling emergence is of epigeal type (which is similar to common bean and lupinus) where the cotyledons come out from the ground during germination. This type of emergence makes cowpea more susceptible to seedling injury, since the plant does not regenerate buds below the cotyledonary node. Leaves are smooth and rarely pubescent. There is a broad range in leaf size and shape. Flowers originate in multiple racemes. Two or three pods per peduncle are common and often four or more pods are carried on a single peduncle. The presence of these long peduncles is a distinguishing feature of cowpea and this characteristic also facilitates harvest. Cowpea primarily is self-

pollinating. Cowpea pods are six to 10 inches long, cylindrical and curved. The flowering period can be altered by warmer and humid conditions, leading to asynchronous maturity. Early-sown crops tend to have elongated internodes, are less erect, more vegetative, and have a lower yield than those sown at the optimum time.

TEMPERATURE AND RAINFALL REQUIREMENTS OF COWPEA AT DIFFERENT STAGES OF DEVELOPMENT



Production parameters

Soil

Cowpea performs well on a wide variety of soils and soil conditions, but performs best on well-drained sandy loams or sandy soils where soil pH is in the range of 5.5 to 6.5. Sandy soils tend to be less restrictive for root growth. Cowpea also does well on acidic soils. On heavy fertile soils, cowpea shows vigorous vegetative growth, but not necessarily a good grain yield. Adaptation to lighter soils is coupled with drought tolerance through reduced leaf growth, less water loss through stomata, and leaf movement to reduce light and heat load under stress. Cowpeas are much less tolerant to cold soils than common beans.

Water

Cowpea is a higher drought-tolerant crop than many other crops. It can grow under rainfall ranging from 400 to 700 mm per annum. Cowpea also has great tolerance to waterlogging. Well-distributed rainfall is important for normal growth and development of cowpeas. Most varieties need a minimum rainfall of 200 mm during a growing season.

Temperature

The temperature range for cowpea growth and development is 20 to 35 °C. For vegetative growth, the best growth is possible with temperatures ranging from 21 to 33 °C, while higher temperatures can cause earlier flowering and flower abscission, resulting in poor pod set. Germination occurs quickly at temperatures above 19 °C, but colder temperatures slow germination. Cowpeas grow best during summer. The base temperature for leaf growth is 20 °C. The flowering period can be extended by warm and moist conditions, leading to asynchronous maturity, even in early flowering varieties.

Adaptability

Cowpea is a warm-season crop well adapted to many areas of the humid tropics and temperate zones. It tolerates heat and dry conditions, but is intolerant of frost. Cowpea is more drought resistant than common bean. Drought tolerance explains why cowpea is such an important crop in sub-Saharan Africa; it can perform well in as little as 300 mm of rainfall. The deep root system helps stabilize the water balance and the canopy covers the ground, preventing moisture escape. These traits are particularly important in the drier regions. The most critical water-requiring period is just prior to and during bloom.

Cowpea in the Sahelian region can experience both heat and drought stress, which forces farmers to use varieties adapted to those conditions (Hall, et al. 2002; Hall, 2004). As much as 1000 kg/ha of dry grain has been produced in a Sahelian environment with only 181 mm of rainfall and high evaporative demand (Hall and Patel, 1985). But in general, changes in temperature and rainfall can create a moderate potential for a decrease in productivity, particularly during emergence and seedling growth, leaf and pod development phases. Screening for heat tolerance under field conditions is difficult in the Sahel, but screening cowpea for reproductive-stage heat tolerance under screen-house conditions during the dry season determined that the daily minimum air temperatures varied from 24-27 °C and daily maximum air temperatures varying from 38-

42 °C. Poor production practices including choice of cultivar, adaptability as well as lack of information on the right plant planting date has contributed to low cowpea productivity. The crop can be harvested in three stages: while pods are young and green, mature and green, and dry.

Cowpea is a short day plant and many cowpea accessions present photoperiod sensitivity with respect to floral bud initiation and development (Ehlers and Hall, 1996; Craufurd et al., 1997). For some varieties, the degree of sensitivity to photoperiod can be modified by temperature (Wein and Summerfield, 1980; Ehlers and Hall, 1996). In West Africa, selection for differing degrees of photosensitivity has occurred in different climatic zones such that pod ripening coincides with the end of the rainy season in a given location, regardless of planting date (Steele and Mehra, 1980). This attribute allows pods to escape damage from excessive moisture and pathogens. Cowpea is very susceptible to a variety of insects and diseases and does not do well in poorly drained and cool areas.

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4.0 GROUNDNUT

Brief overview of the crop

Groundnut (*Arachis hypogaea* L.) is known by many names, including peanut, earthnut, monkey nut, and poor man's nut. Although groundnut is native to South America, it is successfully grown in other parts of the world and has become an important oil seed and food crop in tropical, sub-tropical, and warm temperate zones. Most groundnut is grown in India and China. Millions of smallholder farmers in sub-Saharan Africa also grow groundnut, for food and as a cash crop. Most of the world production of groundnuts is crushed for oil that is used mainly for cooking. The press cake from oil extraction is a feed rich in protein, but is also used to produce groundnut flour, which is used in many human foods. The seeds or kernels are eaten raw, boiled, or roasted, made into confectionery and snack foods, and are used in soups or made into sauces to use on meat and rice dishes. The vegetative residues from the crop are excellent forage.

Senegal is among the world's leading exporters of groundnuts. This crop provides 75 percent of national agricultural production and employs 50 percent of the workforce. In addition to its vital economic role, groundnuts are also an integral part of the Senegalese culture and ways of life. It is believed that groundnut production has led to the environmental degradation of an already fragile ecosystem (the Sahel). It also impedes the production of major food crops such as millet, sorghum, rice and maize.

Geographic distribution and general level of importance in the country

Asia and Africa account for 97 percent of the area under groundnut cultivation. Groundnut is also cultivated to some extent in North and South America, Europe, and Oceania. Asia and Africa account for 92 percent of groundnut production. But, the average yield in Asia (1600 kg/ha) and Africa (856 kg/ha) are low, as the crop is mostly cultivated as rainfed crop. In sub-Saharan Africa, groundnuts are a basic staple crop, cultivated mainly by small-scale farmers both as subsistence and as a cash crop. It is an important source of protein and other nutrients for poor rural communities. In Africa, groundnut yields are traditionally low, due to unreliable rains, little technology available to small-scale farmers, pest and disease occurrence, poor seed variety, and increased cultivation on marginal land.

Life Cycle

Groundnut is a small erect or trailing herbaceous legume, about 15 to 60 cm high. The fruit is a pod with one to five seeds that develops underground within a needle-like structure called a peg. The seeds are rich in oil (38-50 percent), protein, calcium, potassium, phosphorus, magnesium, and vitamins. Groundnuts show five crucial phenological stages: emergence and establishment, vegetative growth, flowering, yield formation (which includes pod setting and pod filling), and ripening. Groundnut emergence is intermediate between hypocotyl elongation and cotyledon emergence. The hypocotyl elongates, but stops before the cotyledons can emerge. The leaves are alternate and pinnate. The groundnut plant can be erect or prostrate with a well-developed taproot and many lateral roots and nodules. Plants develop three major stems.

The flowers are yellow with male and female parts located on inflorescences resembling spikes. One to several flowers may be present at each node and they are usually more abundant at lower nodes. Pegs will grow between 8-14 weeks after pollination and then will turn into horizontal position to mature as a peanut pod. Pods reach their maximum size after 2-3 weeks in the soil and maximum oil content between 6-8 weeks. Flowering continues during part of the yield formation but the pods from the late-formed flowers do not reach maturity.

TEMPERATURE AND RAINFALL REQUIREMENTS OF GROUNDNUTS AT DIFFERENT STAGES OF DEVELOPMENT

Groundnuts	Germination and Seedling Emergence	Stem elongation and Root Development	Stem Growth and Leaf Development	Inflorescence Emergence	Flowering	Pod/Seed Ripening and Harvest	Annual Average Optimal Temperature	Annual Average Optimal Rainfall		
Celsius	Temp	Temp	Temp	Temp	Temp	Temp				mm/year
37							Temp			800
36										700
35										600
34										500
33										400
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Production Parameters

Soil

Groundnuts grow best in well-drained sandy to sandy loam soils with a pH range of 5.5 to 7.0. Saline soils are not suitable because groundnuts have a very low salt tolerance. The crop is adapted to well-drained, loose, friable medium textured soils. Heavy textures cause problems in lifting the crop at harvest. Also, the top soil should be loose to allow the pegs (on which the fruits are formed) to enter the soil easily. Being a legume, groundnut can fix nitrogen from the air. However, a pre-planting nitrogen application is often recommended to assure good crop establishment. Phosphorous requirements are 15 to 40 kg/ha; potassium requirements 25 to 40 kg/ha. Excess of potassium can cause a decrease in yield. For proper kernel formation and pod-filling, 300 to 600 kg/ha of calcium is required at the beginning of pod formation in the top soil where the fruits are formed. Limestone is used when soil acidity needs to be corrected and gypsum when only the Ca level needs to be increased. At pH lower than 6, liming may be necessary to avoid aluminum and manganese toxicity.

Water

Sufficient and well distributed rainfall during the growing season, especially during flowering, pegging and pod formation stages, is essential for maximum yield and quality of groundnut. For good yields, a rainfed crop requires about 500 to 700 mm of reliable rainfall over the total growing period. Some levels of rain required at different stages are: for pre-sowing operations,100 mm; sowing, 150 mm; flowering and pod development, 400-500 mm.

Temperature

Temperature is a major factor influencing the rate of crop development. The mean daily temperature for optimum growth is 22 to 28 °C Temperatures above 35 °C inhibit the growth of groundnut. The optimum mean daily temperature to grow is 30 °C, and growth ceases at 15 °C. For quick emergence, soil temperature has to be above 21 °C. The optimum temperature for most rapid germination and seedling development is about 30 °C. A minimum of 100 days with optimum temperatures during the growing season is necessary for successful groundnut crop production.

Adaptability

Climatic conditions such as temperature and rainfall significantly influence the groundnut production. Warm and moist conditions are more favorable than a cool and wet climate, which results in slow germination and seedling emergence, increasing the risk of seed rot and seedling diseases. Groundnuts require high temperatures and frost-free periods of about 160 days (Cox, 1979; Clifford et al., 1995). They will not attain optimal maturity in regions with fewer heat units during the growing season. Groundnuts are reported to be very sensitive to low temperatures and seeds are recommended to only be planted when the minimum temperature stabilizes above 18 °C. Germination can reach 95 percent when soil temperatures are in the range of 18 °C to 30 °C. The suitable vegetative growth temperature ranges from 20 °C to 30 °C, but at 33 °C growth can decline up to 84 percent. A beneficial temperature for flowering and pod formation is about 28 °C. Higher altitudes with cooler climates are not adequate for groundnut production. The crop is grown between latitudes of 40 °N and 40 °S. Its growing period is 90 to 115 days for the sequential, branched varieties, and 120 to 140 days for the alternately branched varieties

Water availability is a critical factor for groundnut development. Planting is recommended in humid warm soils so that the germination processes can develop properly. Research has shown that poor germination occurs in drier soils (Kumar el al., 2012). Rainfall of 400 to 700 mm a year is indicated as minimum for groundnuts in drier climates (Dreyer et al., 1981). Keating et al (2003) suggest that increasing temperature (and not reduced rainfall) will have the most dramatic impact on crop yields for groundnuts.

Vegetative and reproductive phases show a significant response to water availability. However, excessive soil water is harmful because lack of oxygen in the soil limits the activity of the N-fixing bacteria; this is noted by an unhealthy growth pattern and yellowing of the leaves. Excessive soil water in heavy soils at harvest can cause the pods to be torn easily from the pegs with the pods remaining in the soil. The flowering period is most sensitive to water deficit, followed by the yield formation period. In general, water deficits during the vegetative period cause delayed flowering and harvest, and reduced growth and yield. Water deficits during flowering cause flower drop or impaired pollination, whereas water deficits during the yield formation period cause reduced pod weight. The early part of the yield formation period (pod setting) is particularly sensitive to water deficit.

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5.0 SWEET POTATO

Brief overview of the crop

Sweet potato is a root crop native to the tropics, and requires warm days and nights for optimum growth and root development. Sweet potato is considered as a food security crop, mainly because of its reliable yields. This crop is easily propagated and grows with no inputs on poor soils under a broad range of rainfall patterns. Worldwide, sweet potato is the sixth most important food crop after rice, wheat, potatoes, maize and cassava. More than 105 million metric tons are produced globally each year, 95 percent of which are grown in developing countries. The importance of sweet potato as a food crop is growing rapidly in some parts of the world. In sub-Saharan Africa, it is outpacing the growth rate of other staples. Sub-Saharan Africa produces more than 7 million tons of sweet potato annually, about 5 percent of global production. It should be noted that 50 percent of global supply is destined for human consumption and 30 percent for animal feed, with the remainder being used for seed and other agricultural aspects (CIP, 1994; Woolfe, 1992). Sweet potato is produced all year round in Senegal. However, its production conditions are best toward the end of the dry season (March-May), as its yield is adversely affected by cold weather.

Geographic distribution and general level of importance in the country

Sweet potato is one of the world's most important food crops in terms of human consumption, particularly in Sub-Saharan Africa, parts of Asia, and the Pacific Islands. First domesticated more than 5,000 years ago in Latin America, it is grown in more developing countries than any other root crop. Most sweet potato is grown in the temperate zone; 70 percent of this area is between 20 °N and 40 °N. Sweet potato is highly concentrated in some areas, notably in the lowlands of China and in the mid-elevations of the Lake Victoria area in Africa. In about half the global area of sweet potato cultivation, it is an obligatory seasonal crop because of low temperatures during part of the year (Hijmans et al., 2001).

Life Cycle

Sweet potato can grow at altitudes ranging from sea level to 2,500 m. It requires fewer inputs and less labor than many other crops, such as maize. Sweet potato develops by vegetative propagation. Farmers take stem cuttings from the vines, which then root and form new storage roots. In some colder climates, where vines do not develop well, producers will plant the roots themselves. Botanical seed is used in breeding programs. The plant's vine system expands rapidly horizontally on the ground, and planting material can be easily and quickly multiplied from very few roots. Large, fleshy, edible storage roots are formed on the underground stem nodes. Latex occurs in all parts of the plant. Roots mature on average about four months after planting, with some early maturing varieties ready at two months. Storage roots vary in shape and size according to the cultivar and type of soil where they are grown. Skin color can range from whitish-cream, through yellow-orange and pink to red-purple and very dark purple. Flesh color can be white, cream, yellow, orange, or purple. Some cultivars have a base flesh color with specks or striations in a darker color.

TEMPERATURE AND RAINFALL REQUIREMENTS OF SWEET POTATO AT DIFFERENT STAGES OF DEVELOPMENT

Sweet Potato	Steam / Root Cuttings Seedling development	Root initiation	Shoot Growth	Leaf development	Vine Growth and maturity	Late Growth/ Root Development	Annual Average Optimal Temperature	Annual Average Optimal Rainfall	
Celsius	Temp	Temp	Temp	Temp	Temp	Temp	Temp		**mm/year**
37									1600
36									1500
35									1400
34									1300
33									1200
32									1100
31									1000
30									900
29									800
28									700
27									600
26									500
25									400
24									300
23									
22									
21									
20									
19									
18									
17									
16									
15									

Production Parameters

Soil

Sweet potatoes grow best in loamy soils. The best soil types are well-drained, fine sandy, or clay loams. Light, loamy soils usually result in roots with better shapes than those grown in heavy or clay soils, which results in rough, irregular roots. High (2 percent or more) organic soils can reduce production. Coarse, deep, sandy soils are generally low in fertility, subject to water stress, and require irrigation and fertilizer to grow a good crop. Poor aeration caused by poor drainage decreases yields. With severely impeded drainage, susceptible cultivars can produce either souring (tissue breakdown of the storage roots) or water blisters (enlargement of lenticels on the periderm) if the drainage problem is less severe. Sweet potatoes will grow at a soil pH of 4.5 to 7.5, but 5.8 to 6.2 is optimal

Water

Sweet potatoes grow best with a well-distributed annual rainfall of 600-1600 mm during the growing season. The presence of dry weather favors the formation and development of storage roots. Sweet potato is relatively drought tolerant, however, it cannot withstand long periods of drought; the yield is considerably reduced if drought occurs about the time of planting or root initiation. The crop requires almost 25 mm of water per week uniformly distributed throughout the growing season for highest yields. Conditions after the 6-7 week of planting are particularly critical to development of storage roots

Temperature

The growth is good at temperatures above 25 °C; when temperatures fall below 12 °C or exceed 35 °C, growth is retarded and yield is impacted. In Senegal, sweet potato mostly grows in marginal conditions. The optimum temperature range to achieve sweet potato production is indicated between 21 and 29 °C. The storage roots are sensitive to changes in soil temperature and, depending on the stage of root development, can be expected a slight potential for decrease in productivity.

Adaptability

Sweet potatoes can be grown where there is a long frost-free period with warm temperatures in the growing season. Most cultivars require a minimum frost-free period of 100-125 days. Sweet potato varieties grown in Africa are diverse landraces, selected for adaptation to local environments and for taste. Colors such as white, cream or yellow- fleshed varieties are the norm, and orange-fleshed varieties are still relatively rare. The local standards expect a dry-matter content ranging from 28 to 35 percent. Maturity is variable (3–8 months) and there is a strong preference for varieties that produce vigorous vines that can survive the dry season. Sweet potato is produced all year round in Senegal and production conditions are best toward the end of the dry season (March-May). Yield can, however, be adversely affected by cold weather.

Sweet potatoes can adapt very well to warm climates and grow best during summer and, most developmental stages can counter climate change adequately. Ringler et al. (2010) indicate, however, that sweet potato could be, after wheat, the most affected crop by climate change in sub-Saharan Africa. Significant levels of sunshine and temperatures below 13 °C for several days or 3 °C for one day can damage sweet potato plants.

Remarkably, Biswas et al. (1996) found that increases in atmospheric CO_2 actually can lead to increases in sweet potato growth and yield, which could be a positive impact of climate change in the future.

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6.0 PEARL MILLET

Brief overview of the crop

Pearl millet (Pennisetum glaucum L.) is a high nutritive value summer-annual forage crop, popular among livestock producers for grazing, silage, hay, and green crop. Pearl millet is a highly cross-pollinated (more than 85 percent outcrossing) diploid annual crop. This crop is grown on about 26 million ha in the warm tropics, divided equally between Africa, particularly in the West African Sahel region, and the Indian subcontinent. In these areas, pearl millet is grown almost exclusively as human food, and, in fact, is the staple cereal of 90 million people who live in climate zones where there are severe stress limitations to crop production due mainly to heat, low and erratic rainfall, and poor soils. Since fertilizers are not used and cultivation is by hand or animals, actual grain yields are low in these regions (~500 to 600 kg/ha), yet they are higher and more reliably obtained than from other possible tropical dryland cereal crops such as sorghum or maize. Grain is always the principal object of cultivation, but the stover is secondarily important as animal fodder, and stems can be used as fuel, fencing, and roofing.

Geographic distribution and general level of importance in the country

Pearl millet is a widely grown Old World tropical food cereal well adapted to the hot drought prone areas of Africa and the Indian subcontinent where about 26 million ha (about seven times the United States grain sorghum area) is grown. Archaeological evidence suggests that pearl millet was first domesticated in the grasslands and park lands at the edge of the Savanna-Sahel desert of West Africa ca 2,500 BC, and spread rapidly out from there. Presently, it is an important forage crop of Africa, Asia and America (Dakheel et al., 2009). Pearl millet is extensively used in different countries as forage of high nutritional quality (Maiti and Rodriguez, 2010). Pearl Millet is cultivated in semi-arid regions stretching over 7,000 km from Senegal to Somalia.

Life Cycle

Pearl millet is an erect annual that grows to a height of beteen 50 cm and 4 m. It produces several flowers which are tucked tightly around a cylindrical spike (called rachis). This inflorescence is typically of greenish yellow color. Flowers can be either cross-pollinated or self-pollinated. The female part (stigma) emerges before the male part is ready to shed its pollen. This promotes cross-pollination most of the time; however, where the timing overlaps, some levels of self-pollination are possible. Grain develops as soon as fertilization takes place and is fully developed after 20-30 days. The whole process, from fertilization to ripening, takes only about 40 days. The seeds vary in color (from white to brown, blue, or almost purple). Seeds are commonly in the form of tear. The average weight is about 8 mg. Some thresh free from glumes, while others require husking. The seeds germinate fast if conditions are favorable; they can sprout in about 5 days. Freshly harvested seed may not germinate immediately; however, a dormancy of several weeks after harvesting has been reported. Smallholder subsistence farmers in African rainfed millet farming systems are considered to be highly vulnerable to climate change impacts (Jarvis et al., 2011).

TEMPERATURE AND RAINFALL REQUIREMENTS OF PEARL MILLET AT DIFFERENT STAGES OF DEVELOPMENT

Pearl Millet	Germination and emergence	Seedling growth	Culm elongation and Leaf Development	Panicle initiation and maturation	Flowering and Seed Formation	Grain filling and Ripening	Annual Average Optimal Temperature	Annual Average Optimal Rainfall	
Celsius							Temp		mm/year
37									1100
36									1000
35									900
34									800
33									700
32									600
31									500
30									400
29									300
28									200
27									
26									
25									
24									
23									
22									
21									
20									
19									
18									

Production Parameters

Soil

Like most plants, pearl millet does best in light and well-drained soils. It performs poorly in clay soils and cannot tolerate waterlogging. It is tolerant of subsoils that are acidic (even those as low as pH 4-5) and high in aluminum content.

Water

The optimum rainfall requirement of pearl millet ranges between 400 to 700 mm, but it can be grown in areas with less than 350 mm of annual rainfall. Prolonged spells of warm weather without rain may be detrimental, and may lead to reduced crop yields. At harvest time, dry warm weather is most suitable. Pearl millet is popular in regions where the weather is very unpredictable. Thus, it could be expected to hold high to moderate potential for decrease in productivity. The potential for decreased productivity is linked to drought spells.

Temperature

Pearl millet is a warm weather crop and grows best at temperatures in the range of 20 to 28 °C. For seed germination, temperatures of 23 to 32 °C are required. Pearl millet seed does not germinate or grow well under cool soil conditions. Poor emergence and seedling growth may result if planted before soil temperatures can reach 23 °C. Africa's pearl millet areas have temperatures that are typically above 30 °C. Singh et al. (1998) indicated that temperatures of 10 °C or below stop pearl millet development; the same occurs at 45 °C, which is indicated as the maximum temperature above which no development takes place.

Adaptability

Pearl millet is more tolerant of high temperatures than probably any other cultivated cereal. Although the crop can grow where rainfall ranges from 200 to 1,500 mm, most cultivated areas receive 250-700 mm. Early maturing varieties are planted in the lowest rainfall areas. However, pearl millet requires rainfall to be evenly distributed along of the growing season (unlike sorghum, pearl millet cannot go into dormancy during droughts). Conversely, the excess of rain at flowering stage can cause crop failure. Pearl millet is highly resilient to some of the driest areas of the world, like the Sahel area. The plant is generally sensitive to low temperatures at the seedling stage and at flowering. Winkel et al. (1997) reported that water deficits taking place prior to flowering and at the beginning of flowering cause the flowering of tillers to be delayed or totally inhibited. High daytime temperatures are required for grain development.

The ability of pearl millet to develop under dry environment conditions is due to a number of physiological and morphological characteristics. For example, root penetration is fast and deep (root depths of 3.6 m have been recorded). The roots system has specialized cell walls that prevent desiccation (Payne et al., 1990). The tillering capacity of pearl millet compensates any reduction in yield-contributing components such as number of heads, length of the head, grain weight etc.

Pearl millet is a potentially productive, high-quality grain or silage crop that appears superior to sorghum in its capacity for establishment and production under limited soil moisture (Serraj and Sinclair, 2002; Purcell et al., 2002; Dakheel et al., 2009). This is why researchers world-wide are motivated to introduce this crop in arid and semiarid regions of their countries (Maiti and Rodriguez, 2010).

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7.0 MAIZE

Brief overview of the crop

Maize is an annual grass that can grow up to 4 m tall. It is a warm-weather annual crop with deep-rooted system but requires abundant moisture for best development. It is grown widely throughout the world in a range of agro-ecological environments; worldwide, more maize is produced annually than any other grain. Maize was introduced into Africa in the 1500s, and now represents one of the most crucial cereal crops in the developing world (Bonavia, 2013). It is cultivated in different regions under diverse climatic and ecological conditions and has become a major staple and cash crop for smallholder farmers. Although maize is a grain crop, it is also consumed as a vegetable. The grains are rich in vitamins A, C, and E, carbohydrates, and essential minerals, and contain 9 percent protein. Most maize production in Africa is rainfed. The limited use of nitrogenous fertilizers and declining soil fertility are problems for maize production in sub-Saharan Africa.

Geographic distribution and general level of importance in the country

Maize is a versatile crop grown over a range of agro-climatic zones. In fact, the suitability of maize to diverse environments is unmatched by any other crop. It is grown from 58 °N to 40 °S, from below sea level to altitudes higher than 3,000 m, and in areas with 250 mm to more than 5,000 mm of rainfall per year (Shaw, 1988; Dowswell et. al., 1996) and with a growing cycle ranging from 3 to 13 months (Shaw, 1988). However, the major maize production areas are located in temperate regions of the globe. The United States, China, Brazil, and Mexico account for 70 percent of global production. Maize is a major cereal crop in West and Central Africa, currently accounting for a little over 20 percent of domestic food production in Africa. Its importance has increased as it has replaced other food staples, particularly sorghum and millet (Smith et al., 1994). In sub-Saharan Africa maize is mostly grown by small-scale farmers, generally for subsistence as part of mixed agricultural systems (Smale et al., 2011). Maize is one of the top crops cultivated in Senegal.

Life Cycle

The staging system divides maize development into vegetative and reproductive stages. The vegetative phases include seedling emergence, internode elongations, ear and tassel initiation, stem elongation, and tassel emergence. The reproductive stage includes silking, ripening, and maturity. Silking (pistillate flower maturity) is considered by many as the most critical stage, since it strongly influences kernel quality and yield (Bennetzen and Hake, 2009). Depending on its genetic background, each plant can develop either 20 or 21 total leaves. The plant silks about 65 days after emergence. Most varieties require 100 to 140 days from seeding to full ripeness of the kernels though some kinds will ripen in as little as 80 days (Bennetzen and Hake, 2009). The crop is very sensitive to frost, particularly in the seedling stage, but it tolerates hot and dry atmospheric conditions so long as sufficient water is available to the plant and temperatures are below 45 °C.

TEMPERATURE AND RAINFALL REQUIREMENTS OF MAIZE AT DIFFERENT STAGES OF DEVELOPMENT

Maize	Germination and emergence	Leaf development, stem elongation	Inflorescence development	Flowering, anthesis	Development of fruit, grain development, milking	Ripening, Senescence and Harvesting	Annual Average Optimal Temperature	Annual Average Optimal Rainfall	
Celsius	Temp	Temp	Temp	Temp	Temp	Temp	Temp		mm/year
37									1500
36									1400
35									1300
34									1200
33									1100
32									1000
31									900
30									800
29									700
28									600
27									500
26									400
25									300
24									200
23									
22									
21									
20									
19									
18									
17									
16									
15									

Production parameters

Soil type

Maize plants perform well on most soils, but are negatively impacted when they grow on very heavy,dense clay and very sandy soils. In general, the soil should preferably be well-aerated and well-drained, as the crop is susceptible to waterlogging. The soil fertility requirements for grain production is relatively high, and high-producing varieties need up to about 200 kg/ha N, 50 to 80 kg/ha P, and 60 to 100 kg/ha K. In general the crop can be grown continuously as long as soil fertility is maintained. Maize is moderately sensitive to salinity; yields decrease with increases in soil salinity.

Water

The crop requires a considerable amount of moisture to develop. Between 500-700 mm of well distributed rainfall is favorable for proper growth. Maize plants use water efficiently and thus are relatively drought-tolerant. However, drought can damage maize, especially at its germination and seedling stages. After germination and up to the tasseling stage, the crop can stand less moisture. In general, the plant requires more water during the reproductive period and eventually will require less moisture when the plant is moving into the final steps toward maturity.

Temperature

Maize is a hot season crop and is grown principally in areas where the average temperatures range between 21 and 30^{0}C. The plant requires an average temperature of around 22 °C and night temperatures above 15 °C and requires warm temperatures from germination to flowering in particular. Cultivation is not viable when daytime temperatures are less than 19 °C and temperatures during the first 3 months fall below 21 °C at night. Midday temperatures that reach 35 °C or above for several days can destroy pollen, and cause yields to be drastically compromised and reduced.

Adaptability

The adaptability of maize varieties to different climate conditions varies widely (Fischer et al., 1983). It is very important to select those varieties where the length of their growing period matches the length of the growing season. Variety selection trials to identify the best suitable varieties for given areas are frequently necessary. For example, early grain varieties take 80-110 days and medium varieties take 110-140 days to mature when the average daily temperatures during the growing season are greater than 20 °C. But when temperatures drop below 20 °C, there is an increase in the number of days required to reach maturity, of about 10 to 20 days for each 0.5 °C decrease, depending on the variety, and at 15 °C the maize grain crop can take from 200 to 300 days to mature. In areas where the mean daily temperature is around 10 to 15 °C maize is mostly grown to be used as a forage crop, due to the problems of seed set and grain maturity under cool conditions. In this case, for germination the lowest average daily temperature has to be about 10 °C, with 18 to 20 °C being optimal.

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8.0 FONIO

Fonio (*Digitaria exilis*) , one of the oldest cultivated cereals in Africa, is one of the smallest species of millet. Fonio is grown in tropical climates with average temperatures of 25 to 30 °C and between 900 and 1,000 mm of rainfall. Fonio is considered a staple food in dry areas of several West African countries including Guinea, Gambia, Mali, Burkina Faso, Benin, Senegal, and Togo. It grows in the Sahel belt, a semi–arid landscape located between the Sahara and tropical regions of central Africa, is considered as a coping strategy for increased household food security. Fonio requires little input in its cultivation, and it is highly adapted to drought and low fertility soils; while it is not as drought resistant as pearl millet, fast-maturing landraces, reaching maturity in only 8 weeks, are suited to areas with short and unreliable rains.

9.0 FORAGE SPECIES OF THE FERLO PASTORAL AREA, SENEGAL

The Ferlo in Northern Senegal occupies a total area of 1,150,000 ha. Despite threats to the ecosystem caused by drought and human activities, it is home to a remarkable variety of flora and fauna. The climate is usually dry and, characterized by a long dry season, which can last for up to nine months out of the year. The rainy season is short and produces uneven rainfall carried by humid air masses from the Gulf of Guinea. Due to the arid climate this region is lightly populated. The semi-desert zone of the Ferlo is known for including grass plants which grow naturally. For example, *Andropogon* spp. is a permanent pasture which can be stocked heavily during the wet growing season. It is sometimes used for reclaiming overgrazed land. It has an optimal flowering temperature at 25 °C. Another grass is *Cenchrus* spp., which is an extremely variable species. It produces a deep, strong, fibrous root system to more than 2 m; these grasses are known to withstand drought and are quite tolerant of pests and diseases.

10.0 SUMMARY TABLE OF FINDINGS

SORGHUM

Impact on sorghum productivity in Matam and Kanel departments	Moderate potential for decrease in productivity, particularly during the vegetative stages. However, moderate adaptability in later developmental stages.
Impact on sorghum productivity in Goudery and Bakel departments	Moderate potential for decrease in productivity, particularly during seed germination and initiation as well as emergence and seedling growth. However, shows remarkable adaptability in later developmental stages. Water availability may have a positive impact in early stages.
Striga purple witchweed *Striga hermonthica*	Moderate potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios.
Sorghum downy mildew *Peronosclerospora sorghi*	Moderate potential for increase in prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios.
Anthracnose *Colletotrichum graminicola*	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Sorghum aphid	Moderate potential for increase in prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios.

COWPEA

Impact on cowpea productivity in Matam/Kanel Region	Moderate potential for decrease in productivity, particularly during emergence and seedling growth, leaf, and pod development phases.
Impact on cowpea productivity in Goudery/Bakel Region	Slight potential for decrease in productivity. Would adapt adequately to climate change in most developmental stages.
Hairy Caterpillar *Amsacta moorei*	Moderate potential for increase in prevalence, particularly under decreased rainfall and warmer than normal temperature scenarios.

Charcoal rot or ashy stem blight disease	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios
Cowpea lamptail pod rot, Cowpea blight	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios
Brown blotch, Brown blotch of cowpea	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios
SWEET POTATO	
Impact on sweet potato productivity in both regions	Slight potential for decrease in productivity Would adapt adequately to climate change in most developmental stages.
Nematodes ***Meloidogyne incognita, Radopholus similis***	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Bacterial stem and root rot	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Anthracnose, Blight ***Alternaria bataticola***	Moderate potential for increase in prevalence, with particular sensitivity to temperature.
GROUNDNUT	
Impact on groundnut productivity in Matam/Kanel Region	Very high potential for decrease in productivity in both vegetative and reproductive stages.
Impact on groundnut productivity in Goudery/Bakel Region	Very high potential for decrease in productivity in both vegetative and reproductive stages.
Bacterial wilt of groundnut	Moderate potential for increase in prevalence; particularly sensitive to water availability, and will possibly increase in prevalence under warmer than normal conditions.
Anthracnose	Slight potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature

	scenarios.
Early leaf spot	Low to moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Peanut rust	Low to moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.

FONIO

Impact on fonio productivity in Matam/Kanel Region	Moderate potential for decrease in productivity, particularly during germination and emergence stages.
Impact on fonio productivity in Goudery/Bakel Region	Slight potential for decrease in productivity. Since climate impact is less severe in this region, would adapt adequately to climate change in most developmental stages.
Striga witchweed *Striga senegalensis*	High potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios.
Stem rust	Low potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.

MAIZE

Impact on maize productivity in Matam/Kanel Region	High potential for decrease in productivity in both vegetative and reproductive stages. Potential decrease in productivity linked to decreased rainfall and increased temperature scenarios. Combination of heat and drought can impact plant development.
Impact on maize productivity in Goudery/Bakel Region	High to moderate potential for decrease in productivity in both vegetative and reproductive stages. Potential decrease in productivity linked to decreased rainfall and increased temperature scenarios. Combination of heat and drought can impact plant development.
Sorghum downy mildew	Very high potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios.
Turcicum leaf blight **Northern leaf blight (NLB)**	Very high potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios.

Maize streak virus	Moderate potential for increase in prevalence; particularly sensitive to water availability, and will possibly increase in prevalence under warmer than normal conditions.
PEARL MILLET	
Impact on pearl millet productivity in Matam/Kanel Region	High to moderate potential for decrease in productivity in both vegetative and reproductive stages. The potential for decreased productivity is linked to drought and increased temperature scenarios.
Impact on pearl millet productivity Goudery/Bakel Region	Moderate potential for decrease in productivity, particularly in reproductive stages. Potential decrease in productivity linked to decreased rainfall and increased temperature scenarios.
Phyllosticta leaf blight *Phyllosticta penicillariae*	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Bacterial leaf streak	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Rust *Puccinia substraita*	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
Downy mildew	Moderate potential for increase in prevalence, particularly under increased rainfall and warmer than normal temperature scenarios.
GRASS AND WOODY SPECIES	
Impact on grass productivity	There is an overall moderate potential for decrease in productivity, particularly in vegetative stages of emergence and seedling growth. Potential decrease in productivity is linked mainly to decreased rainfall and the possibility of drought. Some grass species may be more susceptible to drought than others.
Impact on woody species	There is an overall moderate potential for decrease in productivity, particularly in vegetative stages of emergence and

productivity	seedling growth. Potential decrease in productivity is linked mainly to decreased rainfall and the possibility of drought. Some woody species can be more susceptible to decreases in rainfall than others.
Pests and disease in grass/woody species	**Insects and other pests** will have moderate to high potential for increase in prevalence, particularly under warmer than normal temperatures and decreased rainfall scenarios. **Fungal and bacterial diseases** will have low to moderate potential for increase in prevalence. They need water availability to develop, which is not projected under warmer than normal temperatures and highly decreased rainfall scenarios. **Viral diseases** will have moderate to high potential for increase in prevalence. Virus transmission is closely connected to vectors (insects), and their prevalence under increased rainfall and warmer than normal temperature scenarios.

11.0 CROP PESTS AND DISEASES IN SENEGAL - CLIMATE CONSIDERATIONS

MAIZE		
MAIZE PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Larger grain borer *Prostephanus truncatus*[2,3]	Reported for the first time in Senegal in 2007. Attacks farm-stored maize, but can infect the plant before harvest. Adults frequently begin their attack by boring into maize cob cores. Damage can be severe; some reports indicated up to 34 percent.	The insect is tolerant of dry conditions. It can develop at low relative humidity (as low as 40 percent) and as low as 10 percent internal moisture inside maize plants. Develop best at fairly high temperatures (about 30 °C) and high relative humidity (70 percent).
``	Caterpillars are not easily seen on infested crops. Leaves are eaten and the droppings of the caterpillars are conspicuous. During the day they are either found hidden in the heart of the plant or in the soil or trash at the base. Caterpillars bore into the "heart" of wheat and barley and also attack the developing flower spikes	Populations respond favorably to decreased rainfall and high temperatures. High rainfall is an important mortality factor.
Maize weevil	The maize weevil is a major pest of stored maize	Breeding conditions require temperatures

[2] Gueye, M. T., Goergen, G., Badiane, D., Hell, K., & Lamboni, L. (2008). First report on occurrence of the larger grain borer Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae) in Senegal. *African Entomology, 16*(2), 309-311.

[3] Birkinshaw, L. A., Hodges, R. J., Addo, S., & Riwa, W. (2002). Can 'bad' years for damage by *Prostephanus truncatus* be predicted? *Crop Protection, 21*, 783–791.

Sitophilus zeamais[4]	grains in the tropics and temperate regions of the world. Pest causes hollowing of whole previously undamaged grains. In severe infestations only the grain hull is left along with powdery white insect waste. The large emergence holes with irregular edges are characteristic. Grains which float in water often indicate larval damage. Because the maize weevil larvae develop inside the grain, it is difficult to detect the pest by visual inspection unless its numbers are very high.	between 15 and 34 °C and 40 percent relative humidity.
African sugarcane borer[5] *Eldana saccharina*	*E. saccharina* attacks maize during the late vegetative stage, while *S. calamistis* attacks mainly the cobs. The larva makes an exit hole in the stem prior to pupation; this hole often has a large amount of frass hanging from it.	Stressed crops are more liable to be attacked by the borer; therefore, extreme conditions such as drought can favor attacks. Generally reach high level attacks during the second season.
Pink stem borer[6]	Observed in the Senegal River basin area.	Borer populations peak due to low rainfall and high temperatures.

[4] Ileke, K. D., & Oni, M. O. (2011). Toxicity of some plant powders to maize weevil, Sitophilus zeamais (motschulsky) [Coleoptera: Curculiondae] on stored wheat grains (Triticum aestivum). *African Journal of Agricultural Research, 6*(13), 3043-3048.

[5] Asefa, Y, Conlong, D. E., Van den Berg, J., & Le Ru, B. P. (2008). The wider distribution of Eldana Saccharina (Lepidoptera: Pyralide) in South Africa and its potential risk to maize production. *Proceedings of the South African Sugar Technologist's Association, 81*, 290-297.

[6] Warui, C. M., & Kuria, J. N. (1983). Population incidence and the control of maize stalk-borers Chilo partellus (Swinh.), C. orichalcociliellus Strand and Sesamia calamistis Hmps, in Coast Province, Kenya. *Insect Science and its Application, 4*(1-2), 11-18.

Sesamia calamistis	*Sesamia calamistis* predominantly attacks maize ears. Pre-tasseling is the most attractive and susceptible stage of the plant to get attacked. *S. calamistis* attacks mainly the cobs. The larvae of stem borers usually cause the damage. Their feeding leads to death of the growing points, early senescence, "dead heart" condition, reduced translocation, lodging and indirect damage to the ears.	High rainfall is an important mortality factor of stem borers in most agro-ecosystems. Heavy rains in the major season could reduce the incidence of stem borers by preventing contact of males and females for mating, increasing predation, and washing off eggs and newly hatched larvae.
Senegalese Grasshopper *Oedaleus senegalensis*[7],[8]	Senegalese grasshopper is considered the most destructive grasshopper in Senegal, with two to three generations per year. It generally attacks cereals, especially millet and maize Outbreaks are frequent in the Sahelian countries such as Senegal, Mauritania, Burkina Faso, Mali, Niger and Northern Nigeria, especially during wet years following several dry ones Senegalese grasshopper nymphs and adults feed on wild and cultivated grasses. They eagerly feed on the leaves, but prefer seeds in the milky stage.	Major economic impact during the extraordinarily high widespread outbreaks that occurred in 1974, following a long drought in the early 1970s. Distributed within an area where annual rainfall ranges from 200 to 1000 mm. Migration influenced when spatial and temporal rainfall distribution is shifting and erratic, especially at the beginning and end of the rainy season.

[7] Maiga, I. H., Lecoq, M., & Kooyman, C. (2008). Ecology and management of the Senegalese grasshopper Oedaleus senegalensis (Krauss 1877) (Orthoptera: Acrididae) in West Africa: review and prospects. *Annales de la Société Entomologique de France, 44*(3), 271-288.

[8] Cheke, R. A., Jago, N. D., Ritchie, J. M., Fishpool, L. D. C., Rainey, R. C., & Darling, P. (1990). A Migrant Pest in the Sahel: The Senegalese Grasshopper Oedaleus senegalensis [and Discussion]. *Philosophical Transactions of the Royal Society of Biological Sciences, 328*, 539-553.

VIRAL DISEASES	POTENTIAL DAMAGE	CLIMATE/ENVIRONMENTAL CONSIDERATIONS
Maize streak virus (MSV)[9,10] Disease caused by maize streak Geminivirus	Maize streak virus is responsible for sporadic, but severe, outbreaks in maize in sub-Saharan Africa (from Sudan to South Africa and Kenya to Senegal). Yield loss is caused by plant stunting and the termination of ear formulation, development, and grain filling in infected plants. With severe infection, plants can die prematurely. Early disease symptoms begin within a week after infection and consist of very small, round, scattered spots in the youngest leaves.	Many cereal crops and wild grasses serve as reservoirs of the virus and its vectors. Outbreaks of maize streak have been associated with drought and irregular rain in West Africa. As maize streak is vector transmitted, disease outbreaks are dependent on favorable conditions for *Cicadulina* species.
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Sorghum downy mildew (*Peronosclerospora sorghi*)[11]	Sorghum downy mildew has two crop hosts, sorghum and maize. The common symptoms of downy mildew infection on pearl millet, sorghum or maize begin with chlorosis at the base of a leaf which gradually covers	Occurs in many tropical and subtropical regions of the world. The asexual phase occurs in periods of moderate temperatures and high relative humidity.

[9] Shepherd, D. N., Martin, D. P., van, d. W., Dent, K., Varsani, A., & Rybicki, E. P. (2010). Maize streak virus: An old and complex 'emerging' pathogen. *Molecular Plant Pathology, 11*(1), 1-12.

[10] Bosque-Perez, N. A., Olojede, S. O., & Buddenhaggen, I. W. (1998). Effect of maize streak virus disease on the growth and yield of maize as influenced by varietal resistance levels and plant stage at time of challenge. *Euphytica* 101, 307–317.

[11] Jeger, M. J., Gilijamse, E., Bock, C. H., & Frinking, H. (1998). The epidemiology, variability and control of the downy mildews of pearl millet and sorghum, with particular reference to Africa. *Plant Pathology, 47*, 544–569.

	a greater proportion of leaves developed at later stages until the entire leaf is chlorotic.	For infection to occur, a dew period temperature between 10 and 33 °C is required for at least four hours out of the day.
Turcicum leaf blight or northern leaf blight (NLB)[12,13] *Exserohilum turcicum*	Major constraint to maize production in many maize growing regions worldwide with growing seasons of high humidity and moderate temperatures (17 to 27 °C). Yield losses as high as 70 percent have been attributed to *Turcicum* leaf blight. Symptoms are easily recognized. Early symptoms are oval, water-soaked spots on leaves. Mature symptoms are characteristic cigar shaped lesions. Lesions show distinct dark areas as they mature, which are associated with fungal sporulation. Lesions typically first appear on lower leaves, spreading to upper leaves and the ear sheaths as the crop matures. Under severe infection, lesions may coalesce, blighting the entire leaf.	Important disease in most humid regions of the world where the growing season is characterized by temperatures from 17 to 27 °C, and periods of extended dew or leaf wetness. Pathogen overwinters on infected crop debris left on the soil. Turcicum leaf blight is also more prevalent where increased levels of nitrogen fertiliser are applied.
Maize smut[14], [15]	Caused predominantly by the replacement of	More severe in humid, temperate

[12] Carson, M.L. (1999). "Helminthosporium" Leaf Spots and Blights. In White, D. G. (ed), *Compendium of Corn Diseases.* St. Paul, Minnesota: The American Phytopathology Society.

[13] Phytopathology (1991) 73: 722-725. [I AM UNABLE TO FIND THE FULL CITATION FOR THIS – I SUSPECT THERE MAY BE AN ERROR, AS THE VOLUME NUMBER IS NOT CORRECT FOR THE YEAR.]

[14] Banuett, F. (1995). Genetics of Ustilago Maydis, A Fungal Pathogen that Induces Tumors in Maize. *Annual Review of Genetics, 29,* 179-208.

[15] The CIMMYT Maize Program. (2004). *Maize Diseases: A Guide for Field Identification. 4th edition*. Mexico, D.F.: CIMMYT.

Ustilago maydis	kernels with galls. Infection of meristemic tissue in young plants can also lead to plant death, while formation of galls on the stems can interfere with translocation of water and nutrients leading to yield loss.	environments than in hot, humid, tropical lowlands. Nitrogen fertilizer increases disease severity. Later in the season, dry and warm conditions (21-30 °C) favor disease severity. Factors that lead to plant injury such as strong winds, hail, insect damage and blowing soil favor disease severity as *U. maydis* predominantly infects plants through wounds.

SORGHUM		
SORGHUM PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Striga purple witchweed[16],[17] *Striga hermonthica*	Striga is the most serious pest of sorghum. *Striga* attaches itself to sorghum roots, depriving it of nutrients and preventing them from establishing and growing properly.	Striga seeds will germinate only under conditions of favorable moisture and temperature (free moisture adequate for seed imbibition and at temperatures between 20 and 33 °C).
Khapra beetle *Trogoderma granarium*[18]	The khapra beetle is one of the world's most feared stored-product pests. Larvae and cast skins indicated beetle infestation. However, larvae and adults are commonly identified by microscopic examination. Larvae are mostly seen just before dusk, since they are more active at that time	Complete development from egg to adult can occur from 26 to 220 days, depending upon temperature. Optimum temperature for development is 35°C. *Trogoderma granarium* is a serious pest of stored products under hot dry conditions.
Angoumois grain moth *Sitotroga cerealella*[19]	Important stored sorghum pest. It can cause losses of up to 50 percent during storage.	High temperature and poor storage hygiene are major factors resulting in insect infestation.

[16] Watling, J. R., & Press, M. C. (2001). Impacts of Infection by Parasitic Angiosperms on Host Photosynthesis. *Plant Biology, 3*(3), 244-250.

[17] Andrews, F. W. The parasitism of Striga hermonthica Benth. on Sorghum spp. under irrigation: I. Preliminary results and the effect of heavy and light irrigation on Striga attack. *Annals of Applied Biology, 32*(3), 193-200.

[18] Lindgren, D. L., & Vincent, L. E. (1959).Biology and control of Tragoderma granarium Everts. *Journal of Economic Entomology 52*, 312-319.

[19] Seifelnasr YE.(1992). Farmers' perceptions on management practices of insect pests on stored sorghum in southwestern Ethiopia. *Crop Protection, 26*, 1817-1825.

	Infestation can begin in the fields. In storage, the infestation is confined to the upper layer of the grains. The larva bores into the grain and remains there until emerging as an adult from round emergence holes. The infested grain is completely hollowed out and filled with larval excreta.	
Sorghum aphid[20] *Melanaphis saccari* Maize aphid	These aphids are often found sucking on ear heads or on the underside of leaves. They produce large quantities of honeydew, which enable black sooty molds to grow. Attacked plants sometimes are stunted, while leaves dry up, and yield is reduced. Young plants suffering from drought stress may be killed. The maize aphid transmits the maize dwarf mosaic virus to sorghum.	Aphids can be a problem during dry periods. Heavy aphid infestations on sorghum at the booting and heading stages seriously reduce both grain quality and yield
Sorghum midge [21],[22] *Stenodiplosis sorghicola*	It is reported as one of the most important pests of sorghum in some African countries. Eggs are laid in the flowering heads. The small orange larvae feed in the developing seed. Attacked seeds become shrunken and flat, resulting in empty or "chaffy heads" as shriveled grains fail to develop. The larva pupates inside the spikelet, and before	Dry weather favors midges.

[20] Singh, B. U., Padmaja, P. G., Seetharama, N. (2004). Biology and management of the sugarcane aphid, Melanaphis sacchari (Zehntner) (Homoptera: Aphididae), in sorghum: a review. *Crop Protection,23*(9), 739-755.

[21] MacFarlane, J.H. (1989). *Insect Science and its Application,10*, 277–284.

[22] Sharma, H.C., Reddy, B.V.S., Stenhouse, J.W., & Nwanze, K.F. (1994). Host Plant Resistance to Sorghum Midge, Contarinia sorghicola. *International Sorghum and Millets Newsletter, 35(1), 30-41*.

	adult emergence, the pupa wriggles its way to the tip of the spikelet. After adult emergence, the pupal case remains attached to the chaffy spikelet. Damaged panicles have small, transparent, midge pupal cases attached to the tip of the damaged spikelets.	
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Sorghum downy mildew *Peronosclerospora sorghi*[23],[24]	Downy mildew of maize caused by *Peronosclerospora sorghi* is one of the most destructive diseases of this crop world-wide The disease is highly destructive due to the systemic nature of the infection, which results in death of the plants or lack of grain formation in the panicles. Both systemic and local infections occur. Symptoms appear as chlorotic foliage. The first infected leaf shows chlorosis on the lower part of the lamina, which further grows to cover large part of the leaves. The other leaves on a plant that get infected subsequently show more chlorosis.	Infections appear under cool and humid weather conditions.
Anthracnose [25,26,27]	Anthracnose causes severe foliage damage, resulting	Anthracnose most often develops during

[23] Chakrabarty, S. K., Prasada Rao, R. D. J., Varaprasad, K., Singh, S. D., & Girish, G. A. (1998). The Quarantine procedures for sorghum downy mildew - A Note on the past experience. *Indian Journal of Plant Protection* 26, 167-169.

[24] Williams, R. J. (1984). Downy mildews of tropical cereals. In: Ingrams, D., & Williams, P. (eds). *Advances in plant pathology*, Vol 2. Academic Press, London, pp 1–103.

[25] Khan, A., & Hsiang, T. (2003). The infection process of Colletotrichum graminicola and relative aggressiveness on four turfgrass species. *Canadian Journal of Microbiology, 49*, 433–442.

Colletotrichum graminicola	in 46 percent yield loss in West Africa. The anthracnose fungus damages foliage and stems of grain sorghum. On susceptible plants, the stem holding the head (peduncle) becomes infected and a brown sunken area with distinct margins develops. Fungus penetrates the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water and nutrients to the grain, causing poor grain development. The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections.	the warm, humid conditions. Under humid conditions, grey/cream/salmon-colored spore masses are produced. In many instances leaves can be entirely blighted, and when it attacked the stem it is known as "stalk rot."
Covered kernel smut[28,29] *Sporisorium sorghi*	The disease may destroy all kernels in a head replacing them with a cone-shaped gall, or it may affect only portions of a panicle. At harvest time, these galls are broken, and spores contaminate the outer surface of other kernels.	Infections are favored by warm rainy days with high humidity.
Rust [30]	Rust shows on leaves as small blisters rupture and	The fungus grows better in hot and humid

[26] Bergstrom, G. C., & Nicholson, R. L. (1999). The Biology of Corn Anthracnose: Knowledge to Exploit for Improved Management. *Plant Disease, 83*(7), 596–608.

[27] Sutton, B. C. (1968). The appressoria of Colletotrichum graminicola and C. falcatum. *Canadian Journal of Botany, 46*(7), 873–876.

[28] Fischer, G. W., & Holton, C. S. (1957). *Biology and control of the smut fungi*. New York, NY: Ronald Press Company.

[29] Tropical Agric (2004) 6: 11–9 [I AM HAVING TROUBLE FINDING THIS CITATION]

[30] Frederiksen, R. A. (2000). Diseases and disease management in sorghum. In: *Sorghum origin, history, technology, and production*. CW Smith & RA Frederiksen (Eds.). Wiley & Sons, Inc., New York.

Puccinia purpurea	release spores. These pustules occur on both the leaf surfaces. Disease appears when plants are near maturity and infection is confined mainly to mature leaves. Grain yield losses are usually not serious and occurrence of the disease is sporadic. Forage sorghum yields are often affected most.	areas.
Leaf blight [31] *Helminthosporium turcicum*	Attacks sorghum, Sudan-grass and maize. The causal fungus is carried on the seed and also lives in the soil on dead or decaying plant material. So seedlings can become infected readily and either die or develop into stunted plants. Small reddish-purple or yellowish-brown spots usually develop on the leaves of infected seedlings. The spots can kill large parts of the leaves, which then dry to the extent that severely affected plants look as if were burned. Spores are spread by wind or rain and infect other leaves and plants.	Causes seed rot and seedling blight, especially in cool and excessively moist soil. Under warm, humid conditions the disease may cause serious damage by killing all leaves before plants have matured.

[31] Adipala, E., Lipps, P. E., & Madden, L. V. (1993). Occurrence of Exserohilum turcicum on Maize in Uganda. *Plant Disease,* 77, 202-205.

COWPEA		
COWPEA PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Hairy caterpillar *Amsacta moorei*[32]	Occurrence of hairy caterpillar is sporadic, but can be devastating in the drier part of the cowpea production zone, such as in the Louga and St. Louis regions. A single wave of hairy caterpillar can completely destroy fields of cowpea seedlings by eating their leaves. If the wave of hairy caterpillars is late, the cowpea plants may have sufficient vigor and leaf production to out-grow and survive the attack. None of the common landraces of cowpea is resistant to hairy caterpillar.	Pest outbreaks, and hence heavy crop losses, are likely to occur in years of substantial and frequent or intermittent rains during the first 25-30 days after start of moth emergence.
Cowpea aphid *Aphis craccivora*[33], [34]	Cause problems at any time in the growing season, but are most damaging when they infest seedlings during dry weather. Aphids feed on the phloem and are particularly	Cause most damage when they attack seedlings during dry weather. Farmers rely on natural biological control,

[32] Ndoye, M. (1978). Pests of cowpea and their control in Senegal In Singh, S. R., van Emden, H. F., & Taylor, T. A. (Eds.). *Pests of grain legumes, ecology and control*. Academic Press, London, UK, pp. 113-115.

[33] Annan, I. B., Schaefers, G. A., & Tingey, W. M. 1995. Influence of duration of infestation by cowpea aphid (Aphididae) on growth and yield of resistant and susceptible cowpeas. *Crop Protection, 14*(7), 533-538.

[34] Bottenberg, H., Tamò, M., & Singh, B. B. (1998). Occurrence of phytophagous insects on wild *Vigna* sp. and cultivated cowpea: comparing the relative importance of host-plant resistance and millet intercropping. *Agriculture, Ecosystems & Environment, 70*(2/3), 217-229.

	damaging to young growing points causing plants to be stunted. They also transmit viral mosaic diseases. Cowpea landraces have little genetic resistance to cowpea aphid.	rainstorms to wash off the insects and enhance fungal parasitism of the insects, and the capacity of these varieties to resume plant development after the attack because of their indeterminate growth habit. These measures are not very effective if there is a pronounced infestation of cowpea aphid.
Flower thrips *Megalurothrips sjostedti*[35].[36]	Small, thin, shiny, black insects that are most often observed inside flowers. Can cause extensive destruction before flowers, are produced by feeding on floral buds. Flower thrips also can cause some damage to cowpeas grown in the Senegal center-north area around Diourbel and Thies. The landraces grown as sole crops in this area have little resistance to flower thrips.	Rate at which thrips move through their developmental cycle is highly dependent upon environmental conditions, including the temperature and nutrient quality of their food source. Infestation of cowpea plants begin just before flowering. Peak of activity occurring at a temperature 23-24 °C. It has been observed that both temperature and light intensity influence flight.
Cowpea weevil, spotted cowpea bruchid, cowpea seed beetle *Callosobruchus* spp.[37]	The insect attacks the fruiting stage, seeds and all stored grains and products. In the pods, the eggs are cemented to the surface. In seeds, **produces r**ound	Can complete a lifecycle in as little as 28 days (at 30 °C). Adults live only 10-12 days and females lay about 100 eggs.

[35] Salifu, A. B. (1992). Some aspects of the biology of the bean flower thrips *Megalurothrips sjostedti* (Trybom) (Thysanoptera: Thripidae) with reference to economic injury levels on cowpea (*Vigna unguiculata* (L.) Walp). *Revue de Zoologie Africaine, 106*(5):451-459.

[36] Childers, C. C., & Achor, D. S. (1995). Thrips feeding and oviposition injuries to economic plants, subsequent damage and host responses to infestation. In: Parker BL, Skinner, M., & Lewis, T. (Eds.). *Thrips Biology and Management.* New York, USA: Plenum Press.

	holes.	Adults are strong fliers and can travel 2-3 km.
Cowpea witchweed, witchweed *Striga gesnerioides*[38,39]	It is a severe pest of cowpea in Senegal, Mali, Togo, Benin, Burkina Faso, Ghana, Nigeria, Niger, Cameroon, and Chad, causing significant loss of yield. Flowering, fruiting, and vegetative growing stages, the leaves, and the whole plant can all be affected by this weed. The symptoms are commonly not obvious at the start of infestation, but later the leaves suffer from chlorosis and withering. **The whole plant can suffer** reduced growth, dwarfing, and early senescence.	Germination and growth are generally favored by temperatures of 30-35 °C, low soil nitrogen, low soil moisture, and dry air conditions.
Purple witchweed *Striga hermonthica*[40, 41]	*S. hermonthica* is said to be responsible for more crop loss in Africa than any other individual weed species. Countries seriously affected include Cameroon, Cote d'Ivoire, Burkina Faso, Niger, Mali, Senegal,	Germination and growth are generally favored by high temperatures of 30-35 °C, low soil nitrogen, low soil moisture, and dry conditions of the air

[37] Ojimelukwe, P. C., Onweluzo, J. C., & Okechukwu, E. (1999). Effects of infestation on the nutrient content and physicochemical properties of two cowpea (Vigna unguiculata) varieties. *Plant Foods for Human Nutrition, 53*(4), 321-332.

[38] Hartman, G. L., & Tanimonure, O. A. (1991). Seed Populations of *Striga* in Nigeria. *Plant Disease, 75*(5), 494-496.

[39] Berner, D. K., Awad, A. E., & Aigbokhan, E. I. (1994). Potential of imazaquin seed treatment for control of *Striga gesnerioides* and *Alectra vogelii* in cowpea (*Vigna unguiculata*). *Plant Disease, 78*(1), 18-23.

[40] Akobundu, I. O., & Agyakwa, C. W.(1998). *A handbook of West African Weeds*. International Institute of Tropical Agriculture (IITA) Ibadan Nigeria.

[41] Andrews, F. W. (1946). The Parasitism of *Striga Hermonthica Benth*. on Leguminous Plants. *Annals of Applied Biology, 34*, 267-275.

	Togo, Sudan, Ethiopia, Kenya, Uganda, and Tanzania. This parasitic weed attacks all the plant stages: and plant parts, flowering, pre-emergence, seedling and vegetative phase, the leaves, stems, and whole plant. Leaves show yellowish blotches, abnormal patterns, wilt, and reduction in number. **Inflorescences are** delayed and the development is prevented. **The stems get** shortened and abnormal growth. **The whole plant suffers** dwarfism and early senescence.	
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Charcoal rot or ashy stem blight disease *Macrophomina phaseolina*[42]	Can cause substantial damage to cowpea when soils became dry and hot. The infected plants show necrotic lesions on stems, branches, and peduncles. From pod peduncles, the fungus spreads to the pods and invades grains. Heavily infected plants die prematurely due to the production of fungal toxins (e.g., phaseolinone). The most striking symptom is the sudden wilting and drying of the whole plant, with most of the leaves remaining green. The stem and branches are then covered with black bodies, and assume the charcoal or ashy appearance of dead plants.	Charcoal rot is an important disease during hot, dry weather or when unfavorable environmental conditions stress the plant.

[42] Ndiaye, M. (2007). *Ecology and management of charcoal rot (*Macrophomina phaseolina*) on cowpea in the Sahel.* PhD Thesis Wageningen University, the Netherlands.

Lamptail pod rot of cowpea, blight of cowpea, pod rot of cowpea *Choanephora cucurbitarum, Choanephora* spp.	In wet conditions *Choanephora* species can infect green pods at the point where petals remain attached to young pods resulting in a wet pod rot. On cowpea, symptoms begin as water-soaked lesions at the leaf margins and tips. These lesions become dry and turne olive-green to light brown. Numerous spiny, long sporangiophores develop during dry weather, resulting in total necrosis of the entire plant.	Wet weather, high temperature (> 25 °C), and high humidity favor disease development, typically soil-borne
Scab *Sphaceloma* sp.[43],[44]	The fungus attacks the stem, leaves, and pods. Serious disease causing loss of foliage, pods and seeds. In severe case there is complete loss of yield. **S**pots can be seen on both leaf surfaces, cupped. Appearance of small scab lesions along the veins cause leaf distortion and irregular appearance **In the stems, some** oval to elongated lesions can develop, usually surrounded by red or brown elliptical rings. **In the pods,** sunken spots with grey centers develop as well as malformations	Wet weather, high temperature and high humidity favor disease development
Brown blotch, brown blotch of cowpea *Colletotrichum truncatum*.[45]	*C. truncatum* affects all plant stages and parts. The stems, pods, and leaves may be infected without	Anthracnose in maturing plants causes serious losses, particularly during the rainy

[43] Singh, S. R., & Allen, D. J. (1979). Cowpea pests and Diseases. IITA monograph. Manual series No 2. Trop. Grain Legume Entomology, IITA, Ibadan, Nigeria.

[44] Emechebe, A. M. (1980). Scab disease of cowpea (*Vigna unguiculata*) caused by *Sphaceloma* a species of the fungus. *Annals of Applied Biology, 96*(1), 11-16.

	showing symptoms. In the advanced stages, infected tissues are covered with black fruiting spots, which can produce black spines.	period when shaded lower branches and leaves die due to severe infection.
Rust, bean rust *Uromyces appendiculatus*[46]	All of the aerial parts are susceptible to infection. Infection appears at all stages of the plant growth. On the leaves, yellowish-brown small raised blister like spots appear. As infection progresses, the blisters erupt. The spores infect the plant again and defoliation can cause death of the whole plant. In the stem, brown spots, spores, and hyphae are borne internally and externally; the spores can be visible. In the pods, some brown spots can develop and decrease the number of pods per plant. The seeds can suffer malformation and cause decrease in the seed weight.	There can be crop failure if infection takes place in the early stages of plant growth. Overcast conditions and a temperature of 20-25 °C favor the pathogen
BACTERIAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Bacterial blight *Xanthomonas campestris* pv *vignicola*	Can be transmitted from infected seedlings to adjacent plants by raindrops and water splashing. Infection produces chlorotic patches (orange with a yellow halo) and necrotic patches on the leaves.	Disease development favored by humid, cloudy conditions. Halo expression is favored by cool

[45] Singh, S. R, & Allen, D. J. (1979). Cowpea pests and Diseases. IITA monograph. Manual series No 2. Trop. Grain Legume Entomology, IITA, Ibadan, Nigeria.

[46] Stavely, J. R. (1984). Genetics of Resistance to Uromyces phaseoli in a Phaseolus vulgaris Line Resistant to Most Races of the Pathogen. *Phytopathology, 74*(3), 339-344.

	Pathogen can cause cracking and cankers on the stem and peduncles. Disease is endemic to the semiarid Sahelian zone. Senegalese landraces Mame Penda and 58-57 are resistant to bacterial blight.	temperatures (16-20 °C). However, the organism is spread and disease develops very well in warm temperatures as well.
Bacterial halo blight, halo blight of beans, grease spot of beans, bacterial bean blight *Pseudmonas syringae* pv *phaseolicola*[47]	The pathogen infects all the growing stages of the plant. Plant develops water-soaked spots that later become necrotic. The lesions show abnormal colors around the necrotic lesion. In the pods, water-soaked, greasy spots appear, varying in size. The seeds can appear rot and faded. Stems can show girdling and rotting of nodes as well as discoloration.	Optimum growth temperatures for the bacterium are 20-23 °C.
Bacterial brown spot *Pseudmonas syringae* pv *syringae*[48]	On cowpea, *P. syringae* pv. *syringae*, survives in infected seeds and stems. From the seed, it infects the cotyledons, spreads to the leaves, or enters the vascular system, causing systemic infection resulting in stem and leaf lesions.	Disease spread and intensity is favored by rains.
Lamptail pod rot of cowpea, blight of cowpea, pod rot of cowpea *Choanephora cucurbitarum*[49]	*C. cucurbitarum* infects plant tissues that have been damaged either by insects or by physical means. On cowpea, symptoms begin as water-soaked	Disease development is promoted by high moisture conditions.

[47] Allen, D. J., Buruchara, R. A., & Smithson, J. B. (1998). Diseases of common bean. In Allen, D. J., & Lenne, J. (Eds.), *The Pathology of Food and Pasture Legumes*. Wallingford, UK: CAB International, 214.

[48] Hall, R. (1991). *Compendium of Bean Diseases*. St Paul, Minnesota, USA: APS Press.

	lesions at the leaf margins and tips. These lesions become dry and turn olive-green to light brown.	*Choanephora* thrives in a hot, humid climate and grows well at 25 °C or above
VIRAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Cowpea aphid-borne mosaic virus[50], [51]	Transmitted by cowpea aphids. Causes distortion and mottling of the leaves and can stunt the plants. The most effective control is to use varieties with resistance; unfortunately most landraces, including Baye Ngagne, Mame Penda, and 58-57, are susceptible. The use of pathogen-free seeds obtained from disease-free plants can provide a measure that is partially effective when fields are not subjected to an early aphid attack, but certified pathogen-free cowpea seed usually is not available to farmers in Senegal.	Mosaic symptoms are best expressed at moderate temperatures 20-25 °C. Systemic vein necrosis occurs at higher temperatures of 26-32 °C.
GROUNDNUT		
GROUNDNUT PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Groundnut seedbeetle or groundnut bruchid	*Caryedon serratus* is a serious pest of stored groundnuts, particularly when these are still in their	The optimum conditions for development are 30-33 °C and 70-90 percent RH, under

[49] Oladiran, A. O. (1980). Choanephora pod rot of cowpea in southern Nigeria. *Tropical Pest Management, 26*(4), 396-402.

[50] Atiri, G. I., Ekpo, E. J. A., & Thottappilly, G. (1984). The effect of aphid-resistance in cowpea on infestation and development of *Aphis craccivora* and the transmission of cowpea aphid-borne mosaic virus. *Annals of Applied Biology, 104*(2), 339-346.

[51] Bock, K. R. (1973). East African strains of cowpea aphid-borne mosaic virus. *Annals of Applied Biology, 74*(1), 75-83.

Caryedon fuscus, *Caryedon serratus* [52][53]	shells. The damage caused is particularly significant when the nuts are destined for confectionery purposes After hatching, the larva burrows straight through the egg shell and the pod wall, and starts eating the seed. Fully grown larvae sometimes come out through the exit holes made by the previous generations. They often live in the storage sacks and pupate in large numbers at the bottom of the pile of sacks. By this stage, the groundnut seeds are severely damaged for human consumption or oil expulsio .	which conditions the development period is 41-42 days. Breeding can take place between 23 and 35 °C.
Pod bug *Elasmolomus sordidus Aphanus*[54]	The adults and nymphs cause damage by sucking the oil from the kernels. Loss of weight and germinative power, and development of free fatty acids and rancid and bitter taste follow.	Cooler temperatures of the mud in the places where the nuts are stored is suggested as the reason for development of the insects.
BACTERIAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Bacterial wilt of groundnut *Ralstonia solanacearum*[55]	*Ralstonia solanacearum* is the causal pathogen of bacterial wilt, and was previously known as	Bacterial wilt is very destructive especially during hot and wet seasons. Plants wilt and

[52] Southgate, B. J., & Pope, R. D. (1957). The Groundnut seedbeetle, a study of its identity and taxonomic position. *Journal of Natural History: Series 12*, 10(117), 669-672.

[53] Davey, P. M. (1958). The groundnut bruchid, *Caryedon gonagra* (F.). *Bulletin of Entomological Research, 49*(2), 385-404.

[54] Corby, H. D. L. (1947). Aphanus (Hem., Lygaeidae) in stored Ground-nuts. *Bulletin of Entomological Research, 37*(4), 609-617.

[55] Mehan, V. K., Liao, B. S., Tan, Y. J., Robinson-Smith, A., McDonald, D., & Hayward, A. C. (1994). Bacterial wilt of groundnut. Information Bulletin No. 35. Patancheru, India. International Crops Research Institute for the Semi-Arid Tropics.

	Pseudomonas solanacearum Wilt symptoms can be seen 2-3 weeks after planting. The first sign of disease is a curling of one or more leaves. In more advanced stages, the plants may bend over at the tip, appear dry, and eventually turn brown, wither, and die. Infected plants have discolored and rotten roots and pods.	die suddenly Temperature is a major. Widespread in tropical, sub-tropical and warm temperate regions where the mean soil temperature is greater than 15 °C. The incidence and rate of wilting increases with high temperatures and soil moisture.
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Early leaf spot *Cercospora arachidicola* [56]	Spots first appear on the upper surface of lower leaves as faint brown to black pinpoint dots. As the dots enlarge to become brown to dark-brown circular spots, a yellow "halo" generally develops as a border around each spot.	Germination and penetration of aerial plant parts take place during times of high relative humidity. Symptoms develop 10 to 14 days after infection when temperatures are 21 °C or higher. The spores are mainly released when the dew dries and at the onset of rainfall. Wind and splashing rain are responsible of spore dispersal.
Late leaf spot	Like early leaf spot, this disease can also cause	Conidia of *C. personatum* germinate and

[56] Shokes, F. M., and Culbreath, A. K. (1997). Early and Late Leaf Spots. In Kokalis-Burell, N., Porter, D. M., Rodriguez-Kabana, R., Smith, D. H., & Subrahmanyam, P., (Eds.). *Compendium of Peanut Diseases* (2nd Ed.). APS Press, St. Paul, MN.

Cercosporidium personatum[57]	defoliation, reduced yield, and increased incidence of certain soil-borne diseases such as Southern stem rot. As the name implies, late leafspot is most prevalent during the later part of the growing season. Spots are generally darker in color than early leafspot and commonly show no yellow halo.. Results of experiments carried out in southern Senegal (Casamance) showed that this disease can bring about a loss of 30-40 percent in yield.	grow at a lower temperatures than those of *C. arachidicola* Reduced infection at temperatures of 28 °C. Maximum infection occurs at 21 °C .
Aspergillus flavus[58]	Infections will not always reduce crop yields alone. The largest economic cost of this pathogen is a result of aflatoxin production, with serious consequences for the health of people and animals due to the presence of aflatoxin in the seeds and peanut meal. Groundnuts in Senegal are highly susceptible to aflatoxin contamination. The country is one of several aflatoxin hotspots in sub-Saharan Africa The economic importance is clearly observed since 300,000 tons of peanuts are exported from Senegal every year.	Affects plants under conditions of high humidity or rainfall. *A. flavus* is likely to thrive in hot and dry climates. When drought and high temperatures are present, the severity of the disease increases. *A. flavus* is unique in that it is a thermo-tolerant disease and can survive in temperatures that other diseases would not tolerate. *A. flavus* is likely to attack plants that have been damaged by insects or that are stressed otherwise. *A. flavus* can contribute to storage rots, especially when the plant material is stored

[57] Wadia, K. D. R., & Butler, D. R. (1994). Relationships between temperature and latent periods of rust and leaf-spot diseases of groundnut. *Plant Pathology, 43*(1), 121-129.

[58] Diedhiou, P. M., Bandyopadhyay, R., Atehnkeng, J., & Ojiambo, P. S. (2011). *Journal of Phytopathology, 159*(4), 268-275.

		at high moisture levels.
Peanut rust *Puccinia arachidis*[59]	Causes leaf spots in peanuts. Losses from rust are substantial, damage being particularly severe if the crop is also attacked by the two major leaf spot fungi, *Cercospora arachidicola* Hori and *Cercosporidium personatum*	Average temperatures around 20-22°C, over 85 percent relative humidity, and three rainy days in a week, if continued for 2 weeks, favor outbreaks of rust.
Verticillium wilt *Verticillium dahliae*m *Verticillium albo-atrum*[60, 61]	Early symptoms usually appear at the flowering stage and include marginal chlorosis of the leaves, loss of leaf turgidity and leaf curling. Leaf symptoms are generally yellowing and leaflet necrosis, followed by wilting and defoliation. The roots of the infected plants have brown discoloration of the vascular tissues. Occasionally plants die, and the roots of the dead plants are severely rotted	The fungus is capable of infecting plant roots directly or through wounds throughout the growing season between temperatures 21 and 27°C whereas temperatures between 24 and 27°C are best suited for *V. dahliae* growth and survival in the plant.
Anthracnose *Colletotrichum dematium* [62,63]	*Colletotrichum dematium* is worldwide in distribution, especially India, Niger, Nigeria, Sudan, Senegal, Taiwan, Tanzania, Thailand, Uganda, and the United States. Symptoms appear as wedge-shaped lesions on the	Most prevalent in warm humid regions. Some reports indicate that pathogen develops well between 25 to 30 °C.

[59] Subrahmanyam, P., McDonald, D., Gibbons, R. W., & Subba Rao, P. V. (1983). *Phytopathology* 73(2), 253-256.

[60] Pegg, G. F. *(*1974). *Verticillium* Diseases. *Review of Plant Pathology*, *53,* 157–82.

[61] Subrahmanyam, P., Wongkaew, S., Reddy, D. V. R., Demski, J. W., McDonald, D., Sharma, S. B., & Smith, D. H. (1992). Field diagnosis of groundnut diseases. Information Bulletin no. 36. International Crops Research Institute for the Semi -Arid Tropics (ICRISAT). 84 pp.

[62] Ibid.

[63] Gwary et al. (2006) Int. J. Agri. Biol., 8(5): 676-679. [CAN'T FIND THIS CITE WITH CERTAINTY.]

	leaflet tips. Lesions may also develop on the leaflet margins. Necrotic tissue becomes dark brown and tends to fragment along the leaflet margins. The disease may also extend to stipules and stems.	
Root rot, charcoal rot *Rhizoctonia bataticola*, *Macrophomina phaseolina*[64]	Failure of seedlings to emerge from the soil (pre-emergence damping-off) or sudden wilt and death of seedling shortly after emergence (post-emergence damping off) are symptoms of seedling stages. A reddish brown to black decay of the roots, or of the stem near the soil line, are commonly observed on infected plants. Affected seedlings frequently wilt under hot temperatures because of the root and lower stem dysfunction.	Charcoal rot is economically important across a broad range of crops throughout the world, particularly in regions that experience hot, dry conditions during the growing period.
VIRAL DISEASES[65]	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Groundnut rosette disease (GRD) This is a complex of three agents which cause the disease: Groundnut rosette virus (GRV) genus *Umbravirus* and its satellite RNA, and Groundnut rosette assistor virus (GRAV) genus *Luteovirus*[66], [67]	One of the most destructive diseases of groundnut in sub-Saharan Africa. All the three agents must be present together in the host plant for successful transmission of the disease by the aphids (*Aphis craccivora).* Although rosette epidemics are sporadic, yield	Reports indicate that bringing forward sowing dates can help the crop to establish before aphid populations reached their peak. Aphids prefer cool temperatures, dry

[64] Chakrabarty, S. K., Girish, A. G., Anitha, K., Rao, R. D. V. J. P., Varaprasad, K. S., Khetarpal, R. K., & Thakur, R. P. (2005). Detection, seedborne nature, disease transmission and eradication of seedborne infection by *rhizoctonia bataticola* (Taub) butler in groundnut. Indian *Journal of Plant Protection, 33*(1), 85-89.

[65] Reddy, D. V. R. (1991). Crop profile. Groundnut viruses and virus diseases: distribution, identification and control. *Review of Plant Pathology, 70*, 665-678.

[66] Nigam, S. N., & Bock, K. R. (1990). Inheritance of resistance to groundnut rosette virus in groundnut (*Arachis hypogaea* L.). *Annals of Applied Biology, 117*(3), 553–560.

	losses approach 100 percent whenever the disease reaches epidemic proportions. Symptoms occur in two predominant forms, chlorotic and green rosette although other symptomatic forms have been reported.	environments and light airy conditions. Dry years in the early 1980s led to an increase in aphid populations.
Peanut clump virus (PCV),[68]	PCV is at present the most important viral disease in Senegal. This infects groundnut in all regions of Senegal. The virus is widely distributed from the Senegal river to the border with Gambia. It appears that the transmission of PCV through seeds is partly responsible for the increased spread of the disease. The symptoms vary from classical stunting with small dark green leaves, to normal sized plants with different light leaf symptoms such as line pattern or specking. PCV is very difficult to diagnose in the field.	Optimal temperatures vary among virus isolates and often reflect temperatures where the isolate is commonly found. Favored by wet soils, although excessive moisture is not required for severe disease to occur.
Peanut stunt Virus (PSV),[69], [70]	This virus can produce various degrees of stunting, shortening of the petioles, reduced leaf size, mild mottling and malformation of pods.	The infection is related to survival and infection of vectors.

[67] Murant, A. F., & Kumar, I. K. (1990). Different variants of the satellite RNA of groundnut rosette virus are responsible for the chlorotic and green forms of groundnut rosette disease. *Annals of applied Biology 117*(1), 85–92.

[68] Dollet, M., Dubern, J., Waliyar, F., & Manohar, S. K. (1993). *Distribution of Peanut Clump Virus (PCV), a virus with high symptom variability.* International Working Group on Plant Viruses with Fungal Vectors, 25-27 July, 1993, McGill University, Montreal, Canada.

[69] Adams, D. B., & Kuhn, C. W. (1977). Seed transmission of peanut mottle virus. *Phytopathology, 67*, 1126-1129.

[70] Reddy, D. V. R. (1991). Groundnut viruses and virus diseases: distribution, identification and control. *Review of Plant Pathology, 70*(9), 665-678.

	It is transmitted in a non-persistent manner by several species of aphids, including *Aphis craccivora*, *Aphis gossypii*, *Hyperomyzus lactucae*, *Myzus persicae*, *Rhopalosiphum maidis* and *Rhopalosiphum padi.* PSV can also be transmitted by mechanical inoculation.	

FONIO		
FONIO PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Coleoptera as millet grain feeders *Tribolium confusum* and *Ephestia cautella* [71,72]	Cause serious damage in storage. *T. castaneum* is a major secondary pest of cereal grains and their products in storage. Compared to pearl millet, fonio is more resistant to *C. cephalonica*, but is heavily attacked by *T. confusum* and *E. cautella*.	*Tribolium* spp. can complete development within a wide range of temperatures and relative humidity conditions. Adult development can be reached in as little as 19-20 days if the temperature is between 20 °C and 37.5 °C, and the relative humidity is greater than 70 percent. *T. confusum* can develop in environments with relative humidity. as low as 10 percent, a level that is prohibitive for the development of most other stored product insect pests.
Striga witchweed *Striga senegalensis*[73]	The plant *Striga senegalensis* is widespread in the tropics and sub-tropics of Egypt, Gambia, Ghana, Mali, Nigeria, Niger Republic, Senegal, Sudan, etc. This parasitic weed attacks all the plant stages and	Tolerate a wide range of climatic and soil conditions.

[71] Gueye, M. T., & Delobel, A. (1999). Relative susceptibility of stored pearl millet products and fonio to insect infesation. *Journal of Stored Products Research, 35*(3), 277-283.

[72] Haines, C. P. (1991). Insects and arachnids of tropical stored products: their biology and identification. Chatham, Kent: Natural Resources Institute.

[73] Mohamed, K. I., Lytton, J. M., & Riches, C. R. (2001). The Genus Striga (*Scrophulariaceae*) in Africa. *Annals of the Missouri Botanical Garden, 88*(1), 60-103.

	plant parts. It can impact flowering, podding, pre-emergence, seedling and vegetative phases, and the leaves, stems, and whole plant. In West Africa alone, it is estimated that about 40 million ha in cereal production are severely infested by Striga and farmers usually abandon those fields.	Develop in areas of an annual rainfall between 250 to 1500 mm. The optimum temperature for seed germination is between 30-40 °C, with no germination occurring at temperatures lower than 15 °C or higher than 45 °C.
FUNGAL DISEASE	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Leaf spot disease *Helminthosporium* spp., *Phyllachora sphearosperma*[74,75]	This is a fungal disease that produces small spots or lesions of different colors (from reddish brown to purplish black). Lesions take place on the leaves from early spring to late fall. Lesions may increase rapidly in size and become round to oval, oblong, elongate, or irregular. Their centers often fade from an ash-white to pale tan or straw color. The spots are commonly surrounded by a narrow, dark reddish brown to purplish black border.	These diseases reduce vigor and can be very destructive during wet, humid weather, especially in late afternoon and early evening, in poorly drained areas, and where it is shady. The more often and longer the plant remains wet, the greater the chance of disease. Dry periods alternating with prolonged cloudy, moist weather and moderate temperatures promote the disease. Low fertility, or excessive shade and nitrogen fertilization, also favor the development of *Helminthosporium*.
Stem rust	The infections in cereals or grasses tend to take	Severe epidemics occurred in 1948, 1951,

[74] Wilson, J.P. (1999). Pearl Millet Diseases: A Compilation of Information on the Known Pathogens of Pearl Millet, *Pennisetum glaucum* (L) U.S. Department of Agriculture, ARS, Agriculture Handbook No. 716.

[75] Pearce, C. A., Reddell, P. & Hyde, K .D. (1999). A revision of *Phyllachora* (Ascomycotina) on hosts in the angiosperm family *Asclepiadaceae*, including *P. gloriana* sp. nov. on *Tylophora benthamii* from Australia. *Fungal Diversity 3*,123-138.

Puccinia cahuensis[76]	place on stems and leaf sheaths; however, they occasionally can be also found on leaf blades and glumes. The first macroscopic symptom is usually a small chlorotic fleck, which appears a few days after infection. Rust causes stem/leaf damage (loss of photosynthetic area, chlorosis, premature leaf senescence), which leads to incomplete grain filling and yield losses	1952, and 1956 when higher than average temperatures and frequent rains favored infection. In general, it occurs where the growing season is characterized by mild temperatures, high relative humidity, and high moisture.

[76] Leonard, K. J., & Szabo, L. J. (2005). Pathogen profile: Stem rust of small grains and grasses caused by *Puccinia graminis*. *Molecular Plant Pathology, 6*(2), 99-111.

SWEET POTATO		
SWEET POTATO PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Sweet potato tortoise beetle[77] *Aspidimorpha spp.*	Both adults and larvae eat large round holes in the leaves. Attacks are sometimes sufficiently severe to completely skeletonize the leaves and peel the stems. Although their damage is quite conspicuous, they seldom if ever cause yield losses.	At 20 and 25 °C, the percent survival from first instar to adult is 75 and 73 percent, respectively. A constant temperature of 30 °C has a detrimental effect on the larvae.
Sweet potato weevil[78] *Cylas formicarius*	Most serious pest of sweet potato around the world. Up to 97 percent losses in some cases. Causes damage in the field and in storage, and is of quarantine significance. Damage is caused by mining of the tubers by larvae. The infested tuber is often riddled with cavities, spongy in appearance, and dark in color. Tunneling larvae also causes damage indirectly by facilitating entry of soil-borne pathogens. Larvae also mine the vine of the plant, causing it to darken, crack, or collapse. Adults may feed on the tubers, creating numerous small holes. Adult feeding on the foliage seldom is of	Reduced rainfall and lower temperatures can contribute to weevil development. It is reported that more damage takes place during the dry season. Adults survive better at cool temperatures.

[77] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[78] Sutherland, J. A. (1986). A review of the biology and control of the sweet potato weevil *Cylas formicarius* (Fab). *Tropical Pest Management, 32*(4), 304-315.

	consequence. Most important pest in Uganda.	
Stem weevil[79], [80] *Peleropus batatae*	Less common and causes much less damage than *Cylas.*	Warmer conditions favor weevil infestations.
Sweet potato hawk moth, sweet potato hornworm, sweet potato moth[81,82] *Agrius convolvuli*	Caterpillars feed on *Convulvulaceae* such as sweet potato (*Ipomoea batatas*). Can cause complete defoliation of the crop if not controlled. *A. convolvuli* larvae can defoliate sweet potato vines and, even when damage is less severe, harvest is delayed, increasing the likelihood of major attack by the sweet potato weevil, *Cylas formicarius*. Defoliation of pulses results in partial or complete crop failure.	Drought or lower than normal rainfall can impact activity. It is reported that they are more active in the dry season. Consumption of sweet potato leaves was greatest at 30 °C.

[79] Ibid.

[80] Chalfant, R. B. (1990). Ecology and Management of Sweet Potato Insects. *Annual Review of Entomology, 35*, 157-180.

[81] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[82] *Jansson, R. K. (1992). Biological approaches for management of weevils of root and tuber crops: a review. Florida Entomologist, 75*(4): 568-584.

Nematodes[83,84] *Meloidogyne incognita* and *Radopholus similis*	Above-ground symptoms exhibit poor shoot growth, leaf chlorosis, and stunting. Galling of rootlets and severe cracking of storage roots on some varieties or formation of small bumps or blisters on other varieties. There may also be brown to black spots in the outer layers of flesh which are not evident unless the storage root is peeled. Presence can be diagnosed by the pearl-like swollen female nematodes in flesh of storage roots or in fibrous roots, within the galls or dark spots.	Increase in temperature has influence in infection. Penetration, rate of development, and total population of *Meloidogyne incognita* in roots of susceptible and resistant sweet potatoes increases with temperature 24-32 °C.
Mole cricket *Gryllotalpa africana*[85]	Damage caused by mole crickets to plants is mainly by feeding, but in part by tunnelling. Feeding occurs underground on roots, at any time of day or night. At night, in warm, wet weather, mole crickets also will feed at ground-surface level on stems and leaves of plants; they do not climb above ground level. Their propensity to cut the stems of seedling vegetables, leaving the top of the plant and the roots undamaged, but killing the plant, is especially damaging.	Mole crickets are cold-blooded. They cannot move at freezing temperatures, so must remain dormant underground. The temperature must be still higher before they can fly.

[83] Jalata, P., & Russell, C. C. (1972). Nature of Sweet Potato Resistance to Meloidogyne incognita and the Effects of Temperature on Parasitism. *Journal of Nematology, 4*(1),1–7.

[84] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[85] Townsend, B. C. (1983). A revision of the Afrotropical mole crickets (Orthoptera: Gryllotalpidae). *Bulletin of the British Museum of Natural History (Entomology), 46*, 175-203.

VIRAL DISEASES	POTENTIAL DAMAGE	CLIMATE/ENVIRONMENTAL CONSIDERATIONS
Groundnut rosette virus disease[86]	It seems to be widely distributed in East, West, and Southern Africa. The disease involves three pathogenic agents *Groundnut rosette virus*, its assistor satellite RNA, and *Groundnut rosette assistor virus*. Aphids play a role in transmitting the virus. Sporadic but very devastating epidemics of the disease have been reported at various times in many African countries including Congo, Gambia, Malawi, Nigeria, Niger, Senegal, South Africa, Tanzania, and Uganda.	Bringing forward planting dates may help the crop to establish before aphid populations reached their peak. Aphids prefer cool temperatures, dry environments, and light, airy conditions.
BACTERIAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Bacterial stem and root rot[87,88] *Erwinia chrysanthemi*	Aerial symptoms are water-soaked brown to black lesions on stems and petioles. One or two branches may wilt, and eventually the entire plant collapses.	The disease is favored by warm, humid weather. Symptoms may not be visible at temperatures below 27 °C but may appear rapidly at temperatures of 30 °C or higher.

[86] Naidu, R. A., Bottenberg, H., Subrahmanyam, P., Kimmins, F. M., Robinson, D. J., & Thresh, J. M. (1998). Epidemiology of groundnut rosette virus disease: Current status and future research needs. *Annals of Applied Biology, 132*(3), 525-548.

[87] Clark, C.A., Valverde, R.A., Fuentes, S., Salazar, L.F., & Moyer, J.W. (2002) Research for improved management of sweetpotato pests and diseases: Cultivar decline. *Acta Horticulturae, 583*, 103-112.

[88] Huang, L. F., Fang, B. P., Luo, Z. X., Chen, J. Y., Zhang, X. J., & Wang, Z. Y. (2010). First report of bacterial stem and root rot of sweetpotato caused by a Dickeya sp. (Erwinia chrysanthemi) in China. *Plant Disease, 94*(12), 1503.

	Localized lesions on fibrous roots may also be present. On fleshy roots, localized lesions with black margins can be observed on the surface, but more frequently the rotting is internal, with no evidence outside.	
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Charcoal rot[89,90] *Macrophomina phaseolina*	In the field, brown to black, water-soaked lesions on stems and petioles are observed. Eventually, stem may become watery and collapse, causing the ends of vines to wilt. Usually, one or two vines may collapse, but occasionally the entire plant dies. Charcoal rot, caused by the fungus, can cause losses of sweet potatoes in storage, but serious losses seldom occur. Reported in Uganda.	Charcoal rot is an important disease during hot, dry weather, or when unfavorable environmental conditions stress the plant..
Rhizophus soft rot[91,92]	Infection and decay commonly occur at one or both ends of the root, although infection occasionally	Climate has strong influence.

[89] Ray, R. C., & Ravi, V. (2005). Post harvest spoilage of sweetpotato in tropics and control measures. *Critical Reviews in Food Science and Nutrition, 45*(7-8), 623-44.

[90] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[91] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[92] Strange, R. R. Jr., Midland, S. L., Holmes, G. J., Sims, J. J., & Mayer, R. T. (2001). Constituents from the periderm and outer cortex of Ipomoea batatas with antifungal activity against Rhizopus stolonifer. *Postharvest Biology and Technology 23*, 85–92

Rhizopus stolonifer	begins elsewhere. Color of the root is not significantly altered, but an odor is produced that attracts fruit flies to the area. If the humidity is high, the sweet potatoes become heavily "whiskered" with a grayish black fungal growth. This feature distinguishes *Rhizopus* soft rot from other fungal rot infections.	Rotting may be inhibited under dry conditions. But under humid conditions the affected sweet potatoes become soft and watery, and the entire root rots within a few days. Infection is especially likely if the relative humidity is between 75 and 85 percent during storage or transport. Chilling and heat damage also predispose sweet potatoes to infection. Soft rot is very destructive when sweet potatoes are washed, packed, or shipped to market during cold weather.
Alternariosis, anthracnose, blight[93,94] *Alternaria bataticola*	Brown lesions with a typical bull's-eye appearance occur on leaves, especially older leaves. Black lesions appear on petioles and stems. Bases and middle sections are more affected. Death of vines can occur.	Humidity has an impact on *Alternaria.* Disease and lesion size increase with altitude. High relative humidity or free water is necessary for infection and sporulation.

[93] Ames, T, Smit, N. E. J. M., Braun, A. R., O'Sullivan, J. N., & Skoglund, L. G. (1996). Sweetpotato: Major Pests, Diseases, and Nutritional Disorders. International Potato Center (CIP). Lima, Peru.

[94] Van Bruggen, A. H. C. (1984). Sweet potato stem blight caused by Alternaria sp.: A new disease in Ethiopia. *Netherlands Journal of Plant Pathology, 90*, 155-164.

PEARL MILLET		
PEARL MILLET PESTS	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Witchweed *Striga hermonthica, Striga asiatica (L.)*[95]	Important problem in Senegal. Large areas of pearl millet in the Sahel have been devastated by *S. hermonthica.* Striga will parasitize millet plants, preventing root development and nutrient uptake. Severe attack produces leaf wilting and chlorosis. Infected plants may be stunted and die before seed set.	Striga seeds will germinate under conditions of favorable moisture and temperature (free moisture adequate for seed imbibition and at temperatures between 20 and 33 °C).
Millet stem borer *Acigona ignefusalis, Sesamia calamistis*[96,97]	During feeding and development larvae cause two types of damage. Early-sown millet is attacked by first-generation larvae which damage young plants and cause dead-hearts. Seedlings of late-sown millet are exposed to higher populations of second or third-generation larvae which produce extensive tunnels in the stems that may kill the plant. On older plants, stem tunneling may cause lodging	Larvae populations are drastically reduced when temperatures exceed 40 °C.

[95] Williams, R. J., Frederiksen, R. A., & Girard, J. C. (1978). Sorghum and pearl millet disease identification handbook. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Hyderabad, Andhra Pradesh, India. Information Bulletin No. 2.

[96] Nwanze, K F (1989) International Journal of Pest Management, 35 (2): 137-142.

[97] Youm, O., Harris, K. M., and Nwanze, K. F. (1996). Coniesta ignefusalis (Hom. pson), the millet stem borer: a handbook of information. Information Bulletin no. 46. International Crops Research Institute for the Semi-Arid Tropics.

	and panicle damage due to disruption of the vascular system which prevents grain formation.	
Millet earhead caterpillar, millet head miner *Rhaguva albipunctella, Heliocheilus albipunctella*[98,99]	It was very destructive in the Sahelian regions of West Africa in the early 1970s. The flight period of the adult moth coincides with the peak of millet panicle emergence and flowering. Caterpillars eat and finish the larval development inside panicles. During this period the seed head also grows and develops, passing from emergence through flowering to grain-filling and maturity. Larval instars eat florets and peduncles, thereby killing the developing grains, and creating mines around the rachis. When mature they drop to the ground, where they burrow into the soil to pupate, usually close to the host plant.	Pupae carry over to the following season in soil. Soil temperature and moisture are critical in determining the survival of diapausing pupae. Moths become active at 25-29 °C and between 20-30 percent increase in air humidity to >90 percent RH.
Millet grain midge *Geromyia*.penniseti [100]	Millet midges damage flower spikelets leading to poor seed set. It is reported that they cause severe grain yield reduction of mid-season Souna millets, which flower in late September in Senegal. Early sowing allows millet plants to attain maturity	Diapause termination and subsequent emergence of adult midges occurs in response to warm, moist soil conditions. Temperatures between 20 to 30 °C, are optimal for development and emergence.

[98] Nwanze et al (1990) Trop. Pest Man. 36 (1): 59-65.

[99] Nwanze, K. F., & Youm, O. (1995). Panicle insect pests of sorghum and pearl millet : Proceedings of an international consultative workshop, 4-7 Oct 1993, ICRISAT Sahelian Center, Niamey, Niger / Edited by K.F. Nwanze & O. Youm International Crops Research Institute for the Semi-Arid Tropics..

[100] Coutin, R., & Harris, K. M. (1969). The taxonomy, distribution, biology and economic importance of the millet grain midge, *Geromyia penniseti* (Felt), gen. n., comb. n. (Dipt., Cecidomyiidae). *Bulletin of Entomological Research, 59*(2), 259-273.

	before midge populations fully develop.	
VIRAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Maize Dwarf Mosaic Virus[101]	Infected plants express mosaic and mild stunting. The potyvirus is generally aphid (non-persistent) or mechanically transmitted. Pearl millet is susceptible to "A" and "B" strains of MDMV. The expression of the symptoms is not temperature sensitive. There appears to be strain specificity for some of the different hosts. Seed transmission in pearl millet has not been demonstrated.	Transmission related to presence of aphids. Most times dry and cool temperatures can promote outbreaks. Disease incidence is highest where vector populations are high, large number of infected plants are present, and susceptible varieties are cultivated.
Peanut clump disease[102,103]	Infected plants are severely stunted, often showed chlorotic lesions on younger leaves and older leaves are dark green in color. PCV is soil born and is vectored by the persistent, soil-inhabiting root parasite, *Polymyxa graminis*. Pearl millet was reported not to be a host for *Polymyxa* sp. in Senegal but recent experiments proved the contrary.	Infection related to survival of *P. graminis*. Temperate isolates were able to grow and infect over a wide temperature range, fastest development occurred at 17–20 °C. Tropical isolates associated with peanut clump virus had a higher optimum temperature of 27–30 °C.
BACTERIAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL**

[101] Redinbaugh, M. G., Gingery, R. E., & Jones, M.W. (2004). The genetics of virus resistance in maize (*Zea mays* L.). *Maydica 49*, 183-90.

[102] Kanyuka, K., Ward, E., & Adams, M. J. (2003). Polymyxa graminis and the cereal viruses it transmits: a research challenge. *Molecular Plant Pathology, 4*(5), 393–406.

[103] Legrève A., Delfosse, P., Vanpee, B., Goffin, A., & Maraite, H. (1998). Differences in temperature requirements between Polymyxa sp. of Indian origin and Polymyxa graminis and Polymyxa betae from temperate areas. *European Journal of Plant Pathology, 104*, 195–205.

		CONSIDERATIONS
Bacterial leaf streak *Xanthomonas campestris* pv. *pennamericanum*[104]	Symptoms are not clearly defined in the literature but are apparently similar to those of bacterial leaf stripe and streak of sorghum. So the symptoms are seen as narrow, dark-greenish, water-soaked, interveinal streaks of various lengths, on the leaf blades.	Optimal growth occurs between 26 and 30 °C. Rain and high humidity favors development of the disease.
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Downy mildew *Sclerospora graminicola* (Sacc.) Schroet.[105]	The most important fungal disease in Senegal. Symptoms often vary as a result of systemic infection. Leaf symptoms begin as chlorosis at the base and successively higher leaves show progressively greater chlorosis. Severely infected plants are generally stunted and do not produce panicles. Green ear symptoms result from transformation of floral parts into leafy structures.	Asexual sporangia are produced during the night with moderate temperatures and high humidity. Optimum sporangium production occurs at 20 °C. No sporulation occurs below 70 percent relative humidity.
Phyllosticta Leaf Blight ***Phyllosticta penicillariae***[106]	The seedlings can be stunted and develop chlorosis. *Phyllosticta* leaf blight-affected plants are stunted, yellow, and have numerous small lesions. These have	Little is known about the conditions that favor disease development, but the pathogen is disseminated by air-borne

[104] Qhobela, M., & Claflin, L.E. (1988). *International Journal of Systematic Bacteriology, 38*, 362-366

[105] Singh, S. D., King, S. B., & Werder, J. (1993). Downy mildew disease of pearl millet. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Pradesh, India, Information Bulletin No. 37.

[106] Wilson, J.P., & G.W. Burton. (1990). *Phyllosticta penicillariae* on pearl millet in the United States. Plant Disease, 74, 331.

	dark brown margins with a light brown necrotic center. Leaf margins are often necrotic. Small, dark fungal fruiting bodies (pycnidia) are apparent in diseased tissues.	spores and movement of infested crop debris. It is believed that moist and warm weather during the reproductive stages can favor the infection. Plants are most susceptible during the flowering stage from bloom to post harvest.
Rust *Puccinia substriata* [107,108]	On pearl millet, this disease develops small reddish-brown to reddish orange, round to elliptical uredinia which develops mainly on the foliage. As severity of infection increases, leaf tissue will wilt and become necrotic from the leaf apex to base. In infection sites developing late in the season, uredinia are replaced by telia which are black, elliptical, and subepidermal.	This disease is more common in warmer environments and high humidity.
Smut *Moesziomyces penicillariae* [109,110]	Fungus affects the ovaries of pearl millet that are converted into sori with dark brown teliospores. Immature, green sori larger than the seed develop on panicles during grain fill. A single sorus develops per floret. As grain matures,	Aerial populations of sporidia are greatest when minimum and maximum temperatures range between 21 and 31°C and maximum relative humidity is greater than 80 percent.

[107] Singh, S.D., & King, S.B. (1991). Pearl millet rust--present status and future research needs. *International Journal of Tropical Plant Diseases 9*, 35-52.

[108] de Carvalho, A., Soares, D., Carmo, M., Costa, A., & Pimentel, C. (2006). Description of the life-cycle of the pearl millet rust fungus - Puccinia substriata var. penicilliariae with a proposal of reducing var. indica to a synonym. *Mycopathologia, 161*, 331-336.

[109] Wilson, J. P. (1995). Mechanisms associated with the tr allele contributing to reduced smut susceptibility of pearl millet. *Phytopathology, 85*, 966-969.

[110] Diagne-Leye, G., Almaraz-Lopez, T., Sy-Ndir, M, Mascarel, G., Ba, A. T., & Roux, C. (2010). *African Journal of Microbiology Research, 4*(9), 740-747.

	sori change in color from green to dark brown. Sori are filled with dark teliospores.	
Ergot *Claviceps fusiformis*[111]	Cream to pink mucilaginous droplets of "honeydew" ooze out of infected florets on pearl millet panicles. Within 10 to 15 days, the droplets dry and harden, and dark brown to black sclerotia develop in place of seeds on the panicle. Sclerotia are larger than seed and irregularly shaped, and generally get mixed with the grain during threshing.	Sclerotia germinate following rain. Conditions favoring the disease are relative humidity greater than 80 percent, and 20 to 30 °C temperatures. Damage when rain occurs during flowering period

[111] Thakur, R.P., & S.B. King. 1988. Ergot disease of pearl millet. ICRISAT [International Crops Research Institute for the Semi-Arid Tropics], Patancheru,, India, Information Bulletin No. 24.

FORAGE SPECIES OF THE FERLO PASTORAL AREA, SENEGAL

Perennial grasses of good palatability:
Andropogon spp

Annual grasses of good palatability:
Brachiara latta
Brachiaria xantholeuca
Cenchrus biflorus
Cenchrus prieurii
Diheteropogon hagerupii
Echinochloa colona
Eragrostis spp.
Hackelochloa granularis
Panicum laetum
Pennisetum pedicellatum
Schoenefeldia gracilis

Woody species of highest palatability:
Acacia ehrenbergiana
A. laeta
A. mellifera
A. senegal

Woody species of highest palatability (continued):
A. seyal
A. tortilis
Balanites aegyptiaca
Bauhinia rufescens
Boscia salicifolia
Cadaba farinosa
C. glutinosa
Celtis integrifolia
Combretum aculeatum
Commiphora Africana
Crataeva adansoni

Dobera glabra

Faidherbia albida
Feretia apodanthera
Grewia bicolor
Grewia spp.

Maerua crassifolia

Maerua spp.
Pterocarpus lucens
Salvadora persica
Ziziphus Mauritania

GRASS PESTS	POTENTIAL DAMAGE	CLIMATE/ENVIRONMENTAL CONSIDERATIONS
Buffalo treehopper	Feeding actually occurs on the ground where they eat plants, but the damage is caused by the	Dry environments can promote infestation of this insect.

Stictocephala bubalus[112]	punctures made in the plants for egg laying. It may destroy seed crops, in particular in woody species such as Acacia.	
Spiders [113] *Cyclops* spp.	Infestation of spiders can smother young growing apices. Also attacks woody species like *Acacia* and *Celtis* spp.	Spiders can thrive in warmer weather and dry conditions.
Larval stages of *Coleoptera, Bruchids, Lepidoptera,* and *Hymenoptera*.[114]	Larvae of all these genera can attack woody species and damage seeds, which prevents further multiplication of the plants.	Cool temperatures and long periods of dry weather can trigger infestation.
Locusts *Anacridium melanorhodon*[115]	This species is generally found in areas of short grass and scattered trees, the most common trees in such habitats being various species of Acacia, but it may also be found in treeless areas. Of the two subspecies, *A. melanorhodon melanorhodon* occurs in the western part of the distribution area, and *A. melanorhodon arabafrum* in the eastern. Locust attack can defoliate vast areas overnight, as they feed on the leaves.	Long periods of drought followed by rainfall can boost the migration of these insects into new areas.

[112] Dennis, C. J. (1960). The genitalia of the buffalo treehopper, Stictocephala bubalus (Fabricius). *American Midland Naturalist, 64*(2), 459-473

[113] Van den Berg, M. A. (1982). Coleoptera attacking *Acacia dealbata* Link., *Acacia decurrens* Willd., *Acacia longifolia* (Andr.) Willd., *Acacia mearnsii* De Wild. and *Acacia melanoxylon* R. Br. in Australia. *Phytophylactica, 14*, 51-55.

[114] Bogdan, A.V. (1977) *Tropical* Pasture *and Fodder Plants (Grasses and Legumes)*. pp. 249-260. (Longman: London and New York).

[115] El Atta, H. A., Aref, I. M., & Mohager, M. (2011). Efficacy of crude neem seed kernel oil (NSKO) in controlling the tree locust (*Anacridium melanorhodon melanorhodon* Walker), a serious pest of the gum arabic producing tree (*Acacia senegal* L. Willd.) in the Sudan. *Archives of Phytopathology and Plant Protection, 44*, 373-380.

Buffel grass seed caterpillars *Mampava rhodoneura* [116]	These caterpillars can infest *Cenchrus* and other annual grasses. The yield of seed crops can be reduced as they feed on the seed, webbing the heads together.	Cooler temperatures and dry periods can favor the presence of the caterpillars.
Cistanche tubulosa[117]	*Salvadora persica* is an evergreen shrub in the Ferlo pastoral area which is the preferred host of *Cistanche tubulosa*, an obligate phanerogamic root parasite. Seed germination in *C. tubulosa* is dependent on a stimulus from the root of the host.	Seeds of *C. tubulosa* germinate at 23 °C but low germination rate is observed below 18 °C and above 33 °C.
VIRAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Guineagrass mosaic virus (GMV)[118]	Causes reduced yields in grasses in tropical areas. It is not seed-borne but can affect maize. Infected plants show characteristic rhomboid lesions on infected leaves. As disease progresses, various mosaic patterns and chlorotic patches develop, causing early leaf senescence. As long as infected plants are maintained under favorable conditions, the disease does not cause significant damage.	Transmitted by aphids. Infection depends on vector.

[116] Bogdan, A.V. (1977) *Tropical Pasture and Fodder Plants (Grasses and Legumes)*. p. 74. (Longman: London and New York).

[117] Rangan, T. S., & Rangaswamy, N. S. (1968). *Canadian Journal of Botany 46*(3), 263-266.

[118] Lenne, J. M., & Trutmann, P. (1994). *Diseases of Tropical Pasture Plants*. CAB International, UK, Natural Resource Institute, Centro Internacional de Agricultura Tropical (CIAT), Colombia.

Sugarcane mosaic virus (SCMV)[119]	Infects *Brachiara* species. Foliar mottling causes mosaic to oblong chlorotic spots. The oblong necrotic spots are dispersed over the leaves; necrotic local lesions, then systemic mosaic, leads ultimately to necrosis. Mosaic in different variegated patterns, depending on the age of the plant and time of inoculation.	Transmitted by aphids. Infection depends on vector.
Maize Dwarf Mosaic Virus[120]	Infected plants express mosaic and mild stunting. The expression of the symptoms is not temperature sensitive. There appears to be strain specificity for some of the different hosts.	Transmission related to presence of the aphids. Most times dry and cool temperatures can promote outbreaks. Disease incidence is highest where vector populations are high, a large number of infected plants are present, and susceptible varieties are cultivated.
Digitaria striate mosaic virus (DiSMV or DSMV)[121]	Causes chlorotic striations and stripes	Transmitted in nature by the planthopper *Sogatella kalophon,* but not by seeds or mechanical means. Transmission, therefore, depends on the vector.
BACTERIAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Bacterial blight of forage grasses	Wilting and drying up of the tillers or the whole	Considerable damage may occur after long

[119] Sukumar, C., Leath, K. T., Skipp, R. S., Pederson, G. A., Bray, R. A., Latch, G. M. C., & Nutter, F. W. (eds.). *Pasture and Forage Crop Pathology*. American Society of Agronomy, Inc. Crop Science Society of America.

[120] Redinbaugh, M. G., Gingery, R. E., & Jones, M.W. (2004). The genetics of virus resistance in maize (*Zea mays* L.). *Maydica 49*, 183-90.

[121] Loebenstein, G., & Thottappilly, G. (Eds.). (2003). *Virus and Virus-like Diseases of Major Crops in Developing Countries*. Kluwer Academic Publishers, Dordrecht.

Xanthomonas campestris pv. *graminis* *Xanthomonas campestres* pv. *phlei*[122]	plants, sometimes accompanied by leaf necrosis. Yellow stripes turn necrotic along the leaf; distorted growth of the leaves from the sheath or difficulty of cobs (ears, heads) emergence; young leaves have a pale color. Observed in *Brachiara* species.	periods of hot and dry weather, while in cool and wet periods hardly any diseased plants are found.
FUNGAL DISEASES	**POTENTIAL DAMAGE**	**CLIMATE/ENVIRONMENTAL CONSIDERATIONS**
Cladosporium herbarum, Fusarium sp., Ravenelia acaciae-senegalae and R. acaciocola[123,124]	They are common environmental fungi. Abundantly occur on fading or dead leaves of herbaceous and woody plants, and as secondary invaders on necrotic leaf spots. *Acacia senegal* and other woody species are attacked by these diverse fungi.	Develop especially in temperate regions. Under favorable climatic conditions and some levels of humidity, *they* can germinate and grow as an epiphyte on the surface of green, healthy leaves.
Buffel Grass Blight *Magnaporte grisea*, *Pyricularia grisea*[125]	*M. grisea* causes disease on a wide variety of alternative hosts including agriculturally significant plants. It affects annual grasses, like *Cenchrus*. Initial symptoms in the grasses are white to gray-green	Conditions that favor the development of the blight include long periods of free moisture when leaf wetness is required for infection, and high humidity is common.

[122] Miles, J. W., Maass, B. L., do Valle, C. B., & Kumble, V. (1996) *Brachiaria*: Biology, Agronomy and Improvement. Centro Internacional de Agricultura Tropical, Empresa Brasileira de Pesquisa Agropecuaria, Centro National de Pesquisa de Gado de Corte. CIAT Publication; no. 259.

[123] Schubert, K., Groenewald, J. Z., Braun, U., Dijksterhuis, J., Starink, M., Hill, C. F., & Crous, P. W. (2007). Biodiversity in the *Cladosporium herbarum* complex (*Davidiellaceae*, *Capnodiales*), with standardisation of methods for *Cladosporium* taxonomy and diagnostics. *Studies in Mycology, 58*, 105-156.

[124] Gandhe, K. R., & Kuvalekar, A. (2007). Phylogenetic studies in *Ravenelia esculenta* and related rust fungi. *Indian Journal of Microbiology, 47*(3), 212-218.

[125] Talbott, N. J. (2003). On the trail of a cereal killer: Exploring the biology of Magnaporthe grisea. *Annual Review of Microbiology, 57*, 177–202.

	lesions or spots with darker borders produced on all parts of the shoot, while older lesions are elliptical or spindle-shaped and whitish to gray with necrotic borders.	
Blast *Pyricularia grisea* [126]	It is a highly variable pathogen which causes differential responses among grasses. Some grass species are resistant to the various races of the pathogen.	Pathogen is favored by humid conditions and warmer temperatures.
Ergot, head blight *Sphacelia* spp. [*Claviceps* spp., *Claviceps africana* , *Claviceps paspali, Claviceps phalaridis*, *Cepsiclava phalaridis*	Can render grasses toxic and useless as feed or forage. Inflorescence pathogens (eg., *Sphacelia*) are readily transmitted by seed. Ergot has considerable potential to be damaging to seed production of *Brachiaria* spp. The characteristic symptom of this disease is the dark purplish sclerotia (resting body), that develop in place of healthy seed and protrude from the glume. These ergot sclerotia can be up to four times higher than the normal seed.	Cool, wet weather favors germination of the fungus.
Wilt *Fusarium oxysporum*, *Bipolaris* sp., and.[127]	*Fusarium oxysporum* and its various strains are characterized by causing vascular wilt, yellowing of leaf, corm rot, root rot, and damping-off. The most important of these is vascular wilt.	Humidity and warm conditions help the pathogen to infect plants. The fungus can survive in the soil in the absence of roots.
Smut diseases	Frequently this pathogen destroys the inflorescence	Infection occurs mainly at high

[126] Farman, M. L. (2002). *Pyricularia grisea* isolates causing gray leaf spot on perennial ryegrass (*Lolium perenne*) in the United States: Relationship to *P. grisea* isolates from other host plants. *Phytopathology,* 92(3), 245-254.

[127] Brayford, D. (1996). IMI descriptions of fungi and bacteria set 127. *Mycopathologia, 133*(3), 61–63.

Sorosporium antheseriae, S caledonicum, Sphacelotheca monilifera and *Urocystis*[128]	of the plant species that it invades. Fungal infection and colonization weakens plants, making them more prone to death during extended periods of hot, dry weather.	temperature. Optimal temperature for the disease development is 28-30 °C.

[128] Agarwal, V.K., Agarwal, M., Gupta, R.K. & Verma, H.S. (1981). Studies on loose smut of wheat. I. A simplified procedure for the detection of seedborne infection. *Seed Res., 9,* 49-51.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES J – K

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ARCC

African and Latin American Resilience to Climate Change Project

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ANNEX J. ISRA LIVESTOCK PESTS AND DISEASES REPORT

ENQUETES SUR L'EVOLUTION DE LA PREVALENCE DES MALADIES ANIMALES SUITE AUX CHANGEMENTS CLIMATIQUES DANS LES DEPARTEMENTS DE MATAM, KANEL, BAKEL ET GOUDIRY

English Summary

This review of the scientific literature summarizes the state of knowledge regarding the most important diseases afflicting livestock in Senegal and analyses potential climate change impacts on the more common and problematic diseases. It describes the environmental and management factors that affect infection and transmission of each disease, and outlines likely changes in their distribution and severity and, ultimately, damage to livestock.

Valuable as an independent product, this study has also been used to enrich the understanding of current livestock management challenges and opportunities explored in the assessment. It will also be used in conjunction with the other components of the Senegal Climate Change Vulnerability Assessment to produce a broader understanding of the potential impact of climate change on livestock husbandry in the study zone.

The predictions that follow are based on expert opinion. They are not the result of modeling or experimentation. They are intended to highlight potential areas of concern. For greater precision, dedicated research more targeted to geographic zone, livestock species, disease vectors, and the pathogens under consideration would be necessary.

1. Introduction

A travers un contrat liant l'ISRA et l'USAID/Tétra Tech, il a été demandé une étude relative à l'impact potentiel du changement climatique sur les maladies animales notamment le cheptel dans les départements du Sénégal que voici: Matam, Kanel, Bakel et Goudiry.

Le présent rapport comporte un chapitre qui décrit la méthodologie suivie de résultats/discussions et enfin les références bibliographiques consultées.

2. Démarche méthodologique

L'approche utilisée dans la présente étude est basée sur celle utilisée dans le cadre de l'étude d'ARRC Sénégal (2013). La situation sanitaire du cheptel dans les 4 départements est étudiée à partir des données des services vétérinaires des 4 départements mais surtout des statistiques disponibles au niveau des services vétérinaires privés (Tableau).

Tableau : Liste des vétérinaires privés impliqués dans le travail de collecte d'information sur les maladies

Région	Département	Vétérinaires privés
Matam Dr Birame Ndong	Matam	Dr Abdoulaye Fall – layefall1966@yahoo.fr – 33966 13 54 ; 77 634 51 30 ; 77 6382073
		Dr Mohamadou DIENG-diengsala2000@yahoo.fr- 775477788
	Kanel	Dr Doudou NDAO-drdoundao@yahoo.fr- 775057593
		Dr Mawdo NGOM ;- ngomawdo@yahoo.fr- 775459061 ;770612759
Tambacounda Dr Mamadou Moustapha Thiam	Bakel	Assane Ba : 77.570.41.69 / 33.982.62.75 - bassane85@yahoo.com.
		Malick Mbodji - 77.213.41.36 / 70.642.22.88 / 77.934.64.73; malickveto@yahoo.fr;
	Goudiry	Mamadou Diouldé Diallo : 77.636.74.52 / 70.790.82.31 ; - djoulded@hotmail.com

Une fois ces éléments obtenus, la liste des maladies susceptibles d'être rencontrées au niveau de chaque département est établie.

Trois ateliers regroupant des spécialistes des maladies animales : parasitaires, bactériennes et virales ont été organisés. Pour chaque pathologie, il est indiqué les lacteurs affectant les maladies vectorielles et la transmission des agents pathogènes et selon les scénarii de changement climatique, il est donné dans le court et moyen terme, les impacts attendus du changement climatique d'une part sur la répartition spatiale de l'infection et d'autre part sur le risque épidémiologique et les pertes liées aux maladies. A cet effet, les données de littérature à travers la documentation sur papier et à travers le net sont utilisées.

3. Résultats/Discussions

Le tableau suivant classe les différentes pathologies selon leur virulence et par espèces animales.

Tableau : Classification des pathologies selon leur niveau de virulence

Légende utilisée Forte: 1 ; Modérée: 2 ; Faible: 3; Mineure/Sporadique : 4

Bovins

Maladies à transmission directe (animal, sol,végétal, etc.)	Niveau de virulence
Pasteurellose (B)	**2**
Charbon symptomatique (B)	**1**

Botulisme (B)	**1**
Septicémie hémorragique (B)	**2**
Péripneumonie contagieuse bovine (B)	**1**
Fièvre aphteuse (V)	1
Parasitisme gastro-intestinal (P)	2
Coccidiose (P)	4
Gale/Teigne (P)	3
Maladies à transmission vectorielle	
Cowdriose (B)	**1**
Anaplasmose (B)	**2**
Fievre Vallée Rift (V)	**1**
Trypanosomose (P)	**1**
Dermatose nodulaire bovine(V)	2
Maladies à transmission par HI	
Distomatose (P)	2

Ovins

Maladies à transmission directe (animal, sol,végétal, etc.)	Niveau de virulence
Pasteurellose (B)	**2**
Entérotoxémie (B)	**2**
Anthrax (B)	**1**
Piétin (B)	**1**
Peste des Petits ruminants (V)	1
Clavelée (V)	2
Ecthyma contagieux (V)	3

Parasitisme gastro-intestinal (P)	2
Pullicose (P)	3
Gale (P)	**3**
Maladies à transmission vectorielle	
Trypanosomose (P)	2
Fievre Vallée Rift (V)	1
Cowdriose (B)	**1**
Anaplasmose (B)	**2**
Maladies à transmission par HI	
Distomatose (P)	**3**
Schistosomiase (P)	**2**

Caprin

Maladies à transmission directe (animal, sol,végétal, etc.)	**Niveau de virulence**
Pasteurellose (B)	**2**
Piétin (B)	**2**
Ecthyma contagieux (V)	**3**
Peste des Petits ruminants (V)	**1**
Teigne (P)	**3**
Parasitose gastro-intestinal (P)	**2**
Gale (P)	**2**
Maladies à transmission vectorielle	
Cowdriose (B)	**1**
Anaplasmose (B)	**2**

Equins

Maladies à transmission directe (animal, sol,végétal, etc.)	Niveau de virulence
Gourme (B)	1
Botulisme (B)	1
Lymphangite épizootique (B)	2
Gale (P)	3
Parasitisme gastro-intestinal (P)	4
(P)	
Maladies à transmission vectorielle	
Trypanosomose (P)	1
Peste équine (V)	1
Habronémose	1

Asins

Maladies à transmission directe (animal, sol,végétal, etc.)	Niveau de virulence
Gourme (B)	1
Maladies à transmission vectorielle	
Trypanosomose (P)	3

Volaille

Maladies à transmission directe (animal, sol,végétal, etc.)	Niveau de virulence
Maladie de Newcastle (V)	1
Variole (V)	2
Parasitisme gastro-intestinal(P)	4
Coccidiose (P)	2

Bovin

1. Maladies à transmission directe (animal, sol, végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
Péripneumonie contagieuse bovine (B) (*Mycoplasma mycoïdes* sub sp mycoides	**Conditions environnementales**: Augmentation de l'humidité améliore la prolifération des germes →fréquences accrues et exposition plus régulière du bétail à la pasteurellose ; Aridité accrue a un effet opposé ; les températures chaudes réduisent la survie des germes dans le milieu extérieur	Chaud/humide	nombrecroissant de germes	Nombre important de Pasteurelles	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et des pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
	Gestion du bétail et occupation de l'espace En condition aride, migration plus fréquente du bétail dans les zones non infectées et dans les zones endémiques.pour l'obtention de meilleures conditions alimentaires	Chaud/Sec	Nombre réduit de germes s	Nombre plus réduit de Pasteurelles	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →pertes plus importantes

Septicémie hémorragique (B) *(Pasteurella multocida)*	**Conditions environnementales**: **Conditions environnementales**: Augmentation de l'humidité améliore la prolifération des germes sous leur forme végétative →fréquences accrues et exposition plus régulière du bétail à l'environnement tellurique en raison de la persistance des formes végétatives ; Aridité accrue entraine une prolifération plusimportante des germes sous leur forme sporulantea→ les températures chaudes ne réduisent pas la survie des germes par le biais des spores : **Gestion du bétail et occupation de l'espace** En condition aride, migration plus fréquente dans les zones non infectées et dans les zones endémiques avec la persistance des spores dans les sols contaminés (prolifération importante des spores).	Chaud/humide	Nombre croissant de germes	Nombre plus important de germess	Stabilité endémique dans les zones nouvellement infectées s →risque accru de maladie avec des pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant de germes avec la multiplication des formes sporulantes.	Nombre plus croissant de germes →	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →p pertes plus importantes
Pasteurellose (B)	**Conditions environnementales**: augmentation de l'humidité améliore la prolifération des germes sous leur forme végétative avec la saison des pluies→fréquences accrues et exposition plus régulière du bétail à *Clostridium chauvoei* ; En cas d'aridité accrue, on a l'même effet , les températures chaudes favorisent la prolifération des formes sporulantes de la bactérie dans les sols contaminés.	Chaud/humide	Nombre croissant de germes avec la multiplication des formes végétatives)	Nombre plus important de de germes sous leur forme végétatives	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant de germes avec la	Nombre plus important de formes sporulantes	Réduction du nombre de germes et l'état d'exposition et du	Arrêt de l'exposition et du risque de maladie → pertes plus

	Gestion du bétail et occupation de l'espace Sous condition aride, migration plus fréquente dans les zones non infectées et dans les zones endémiques avec une sporulation importante se produit(accentuée par une plus s grande présence de cadavres d'animaux sources potentiels de contamination par *Clostridium chauvoei* lors du picage.		multiplication des spores)		risque de maladie → diminution des pertes	importantes
		Chaud/Sec	Nombre croissant de germes avec la multiplication des formes sporulantes.	Nombre plus croissant de germes →	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →p pertes plus importantes
Botulisme (B) ***(Clostridium botulinum)***	**Conditions environnementales**: augmentation de l'humidité améliore la prolifération des germes sous leur forme végétative avec la saison des pluies→fréquences accrues et exposition plus régulière du bétail à *Clostridium chauvoei* ; En cas d'aridité accrue, on a l'même effet , les températures chaudes favorisent la prolifération des formes sporulantes de la bactérie dans les sols contaminés. **Gestion du bétail et occupation de l'espace** Sous condition aride, migration plus fréquente dans les zones non infectées et dans les zones endémiques avec une sporulation importante se produit(accentuée par une plus s grande présence de cadavres d'animaux sources potentiels de contamination par *Clostridium chauvoei* lors du picage.	Chaud/humide	Nombre croissant de germes avec la multiplication des formes végétatives)	Nombre plus important de de germes sous leur forme végétatives	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant de germes avec la multiplication des spores)	Nombre plus important de formes sporulantes	Réduction du nombre de germes et l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie → pertes plus importantes

Fièvre aphteuse (V)	**Conditions environnementales**: Conditions humides favorisent la survie et la transmission à longue distance du virus dans les aérosols infectieux Aride, germe ne résiste pas dans le milieu extérieur **Gestion du bétail et occupation de l'espace** Sous aride transmission plus probable due aux contacts plus fréquents des troupeaux aux points d'eau / sur les pâturages surchargés de même que la migration des troupeaux sur de longues distances	Chaud/humide	Pas d'impact de CC clair	Le risque et les pertes liées à la FA sont stables
		Chaud/Sec	Pas de changement - Plage de fièvre aphteuse couvre déjà l'ensemble du Sahel	Foyers de fièvre aphteuse plus fréquents → pertes de production plus élevées (surtout chez les métisses issus de l'insémination artificielle et les veaux)
Parasitisme gastro-intestinal (P) (Strongles, Strongyloides, etc.**)**	**Conditions environnementales**: Sous scénario de CC humide, augmentation de la durée de vie et de l'activité des larves infectantes dans les pâturages → parasitisme plus important; En cas d'aridité, les œufs excrétés dans le milieu extérieur ne vont pas évolué en larve L3 → pas de risque d'infestation → réduction de l'importance du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente la dissémination des parasites en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système intensif (mobilité réduite)	Chaud/humide	Pas de changement - mais la période de transmission plus longue augmente la densité de larves infestantes dans les pâturages	Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité ; Risque de dissémination plus forte → infestation d'un grand nombre d'animaux
		Chaud/Sec	Pas de changement - mais la période de transmission plus courte réduit la densité de larves infestantes dans les pâturages	Charge endoparasitaire plus faible → augmentation des performances de production et diminution de la mortalité et de la morbidité
Coccidiose (P) **(*Eimeria* sp)**	**Conditions environnementales**: Sous scénario de CC humide, augmentation	Chaud/humide	Pas de changement : Les ookystes restent infestantes en terre →Favorise la dissémination des	Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de

	de l'activité des ookystes de coccidies dans les pâturage → parasitisme plus important; En cas d'aridité, sporulation des ookystes et réduction de l'efficacité de l'infestation **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente la dissémination des ookystes en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système intensif (mobilité réduite)		parasites	morbidité, Risque de dissémination plus forte → infestation d'un grand nombre d'animaux
		Chaud/Sec	Pas de changement : La forme de vie ralentie (spores) → Ralentissement de la dissémination	Charge endoparasitaire faible→ augmentation des performances de production et diminution de la mortalité et de morbidité
Gale/Teigne (P) **(*Sarcoptes scabei*; *Pseuroptes* sp**	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important; En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système intensif (mobilité réduite)	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains	Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,
		Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible→ augmentation des performances de production et diminution de la mortalité et de morbidité

2. Maladies à transmission vectorielle

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
Cowdriose (B) *(Ehrlichia ruminantium)*						
Anaplasmose (B) (*Anaplasma sp.*)	**Conditions environnementales**: humidité accrue améliore la reproduction et l'activité d'alimentation des tiques → Exposition des bovins aux maladies transmises par les tiques; aridité accrue a un effet contraire; Températures élevées réduisent la survie des tiques. Dans des conditions chaudes et humides, taux de survie plus courte est compensé par un taux de reproduction élevé de tiques	Chaud/humide	Population croissante de tiques infectées	Plus grande population l de tiques infectées	Pas de Stabilité endémique dans les zones nouvellement infestées → risque accru d'apparition de la maladie avec des pertes plus élevées	Stabilité endémique plus nette → risque de maladie réduit →diminution des pertes
		Chaud/Sec	Réduction du nombre de tiques infectées	Pourcentage de tiques infectées	Réduction de l'exposition et	Instabilité endémique avec un

	Gestion du bétail et occupation de l'espace : La mobilité des troupeaux entraine la prolifération des tiques en conditions chaudes et humides des zones infestées vers les zones non En conditions chaudes et arides entrainent la diminution de la prolifération des tiques et migration des zones infestées vers les zones non infestées			plus réduit	du risque de maladie →diminution des pertes	risque plus accru d'apparition de cas graves sporadiques → augmentation des pertes
Fievre Vallée Rift (V)	**Conditions environnementales:** Fortes pluies avec inondations → intense reproduction des moustiques → forte interaction entre vecteur /hôte favorisant la transmission du virus →influence du vent sur de longues distances propagation des moustiques infectés **Les conditions arides sont défavorables au, développement du germe Gestion du bétail et occupation de l'espace** L'existence des périmètres irrigués favorise les conditions de transmission du virus chez le bétail de manière significative	Chaud/humide	Extension de la zone à risque de la FVR (effet des variations de la vitesse du vent?) Exemple extension du foyer de FVR du Désert de la Mauritanie en 2010 au nord du Sénégal en 2013 !!!		Précipitations extrêmes et plus fréquentes raccourcissent les intervalles entre les flambées de FVR → poussées plus fréquentes et des pertes plus élevées	
		Chaud/Sec	Zone réduite au risque de la FVR (effet des variations de la vitesse du vent?)	Zone endémique FVR foyers dans les zones d'irrigation, de nouvelles zones à risque	Précipitations extrêmes moins fréquentes prolongent les intervalles entre les flambées de FVR → moins de foyers et moins de pertes	En raison des changements dans les systèmes de production (cultures irriguées), les foyers de FVR se produisent indépendamment de la pluviométrie → avec des pertes plus élevées

Trypanosomose (P) ***Trypanosoma vivax, Trypanosoma congolense, Trypanosoma brucei***	**Conditions environnementales:** Conditions humides sont propices au développement, à la reproduction et à l'alimentation des tsé-tsé →infection trypanosomienne du bétail plus fréquente, une aridité accrue peut conduire à la diminution des vecteurs biologiques (Tse Tse) et à l'émergence de vecteurs mécaniques (Stomoxes et Tabanides) qui peuvent conduire à une transmission sporadique des trypanosomes. **Gestion du bétail et occupation de l'espace** Le déplacement des troupeaux vers les zones infestées de Tse Tse augmente le risque. Tandis que les animaux des systèmes intensifs sont moins exposés au risque trypanosomien	Chaud/humide	Augmentation des densités glossiniennes	Conditions écologiques plus favorables pour l'habitat des glossines et augmentation des densités glossiniennes.	Forte pression glossinienne → Pertes élevées	En zone d'enzootie → transmission continue mais pertes moindres, En zone nouvellement infectée → pertes très importantes
		Chaud/Sec	Diminution des vecteurs biologiques mais transmission sporadique assurée par les vecteurs mécaniques → incidence trypanosomienne faible	Diminution progressive des vecteurs biologiques et mécaniques → incidence trypanosomienne quasi nulle	Transmission biologique très réduite → Réduction des pertes dans les zones faiblement infestées de glossines	Disparition des vecteurs et de la maladie →Faibles pertes liées à la maladie
Dermatose nodulaire bovine(V) **(Virus de la DNCB)**	**Conditions environnementales**: Augmentation de l'humidité entraine des taux de reproduction élevés et de plus longues périodes d'activité des insectes piqueurs → population croissante des insectes piqueurs infectés; Augmentation de l'aridité a l'effet inverse ; la vitesse du	Chaud/humide	Déplacement des Insectes infectés par le vent peut participe à la dissémination du virus		Accroissement de la fréquence de propagation des insectes piqueurs infectés →risque accru d'épidémies	
		Chaud/Sec	Réduction de la population d'insectes infectés → moins de dissemination		Possibilités réduites de propagation des	

	vent est importante pour la propagation des insectes infectés **Gestion du bétail et occupation de l'espace** : Pas d' effet significatif			insectes piqueurs infectés → moindre risque d'épidémie	

3. Maladies à transmission par hôte intermédiaire

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long terme	Long terme	Court terme
Distomatose (P) ***Fasciola gigantic***	**Conditions environnementales**: Sous scénario de CC humide, développement des mollusques (hôte intermédiaire) qui excrètent les cercaires → augmentation du risque d'infestation au niveau des points d'eau → parasitisme plus important; En cas d'aridité, absence d'hôte intermédiaire → pas de transmission **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente l'infestation au niveau des points d'eau en conditions humides dans le système extensif (mobilité à grande échelle) mais absence d'infestation dans le système d'élevage intensif (mobilité réduite)	Chaud/humide	Période de transmission longue et plus forte prolifération des mollusques au niveau des points d'eau → forte émission de cercaires dans les points d'eau		Charge parasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque élevé d'émission de cercaires par hôte intermédiaire → infestation d'un grand nombre d'animaux	
		Chaud/Sec	Absence d'émission de cercaires → incidence nulle de la distomatose → pas de dissémination vers des zones indemnes		Absence de transmission → pas de cas nouveaux → augmentation des performances de production et diminution de la mortalité et de morbidité	

Ovin

1. Maladies à transmission directe (animal, sol, végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
Pasteurellose (B) ***Pasteurella.sp***	**Conditions environnementales:** augmentation de l'humidité améliore la prolifération des germes cibles →fréquences accrues et exposition plus régulière du bétail à la pasteurellose ; aridité accrue a un effet opposé, les températures chaudes réduisent la survie des germes	Chaud/humide	Nombrecroissant de Pasteurelles	Nombre plus important de germes	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
	Gestion du bétail et occupation de l'espace En conditions d'aridité, germe opportunistes sont retrouvés dans les voies respiratoires supérieures. Leur dévloppement est favorisé par l'état de stress liés aux déplacements du bétail pour l'obtention de meilleures conditions alimentaires	Chaud/Sec	Nombre réduit de germes.	Nombre plus réduit de germes plus réduit	Réduction de l'exposition et le risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie → pertes plus importantes

Entérotoxémie (B) *(Clostridium perfringens, ..)*	**Conditions environnementales:** augmentation de l'humidité améliore la prolifération des des formes végétatives de *Clostridium perfringens* →fréquences accrues et exposition plus régulière du bétail à *Clostridium perfringens ;* aridité accrue a un effet semblable avec une prolifération accrue des formes sporulantes de *Clostridium perfringens* dans les sols contaminés : **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride où il y'a persistance des spores pour assurer au bétail de meilleures conditions alimentaires	Chaud/humide	Nombre de croissant de germes sous leur forme végétative	Nombre plus important de germes.	Stabilité endémique dans les zones nouvellement infectées ns →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant de germes sous leurs formes sporulantes	Nombre plus important germes avec la multiplication des spores de *Clostridium perfringens*	Réduction de l'état l'exposition etdu risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie → pertes plus importantes
Anthrax (B) (*Bacillus anthracis*	**Conditions environnementales:** augmentation de l'humidité améliore la prolifération des formes végétatives de *Bacillus anthracis* →fréquences accrues et exposition plus régulière du bétail à *Bacillus anthracis;* aridité accrue entraîne une prolifération des formes sporulantes : **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride (multiplication importante des spores en milieu tellurique)	Chaud/humide	Nombre croissant de formes végétatives de la bactérie	Nombre plus important de formes végétatives de la bactérie.	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant des formes sporulantes	Nombre plus important de spores de Bacillus anthracis	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes
Piétin (B)	**Conditions environnementales** Augmentation de l'humidité améliore la prolifération des Champignons	Chaud/humide	Nombre croissant de Champignons	Nombre plusimportant de champignons	Stabilité endémique dans les zones	Stabilité endémique bien installée dans les zones nouvellement

Oculimacula yallundae, *Fusobacterium necrophorum*, etc..	→fréquences accrues et exposition plus régulière du bétail à *Oculimacula yallundae*, un champignon pathogène; Aridité accrue a un effet opposé, les températures chaudes ne sont pas favorables à la survie des champignons. . **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride (prolifération de champignons pathogènes)				nouvellement infectées ne sont pas encore établies →risque accru de maladie et pertes plus élevées(accroissement de la morbidité	infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre réduit de champignons Gamme contractant les champignons et germes infectés	Nombre beaucoup plus réduit de champignons car très sensibles à la chaleur.	Réduction de l'exposition et de l'état de risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →pertes plus importantes
Peste des Petits ruminants (V)	**Conditions environnementales:** Conditions humides et l'ombre (température plus basse) de transmission de faveur de virus **Gestion du bétail et occupation de l'espace :** Sous aride, transmission plus probablement due au fait des contacts beaucoup plus fréquents des troupeaux au niveau des points d'eau / sur les pâturages excessifs et dissémination de la maladie sur de longue distance avec la transhumance des troupeaux de petits ruminants et des dromadaires :	Chaud/humide	Expansion spatiale possible sur vers la bassin de la méditerrannée et menace pour les pays au Sud de la méditerranée d' autant plus ; la PPR couvre déjà l'ensemble du Sahel – alors qu' historiquement était plus fréquents dans les zones sub-humid/humid Afrique de l'Ouest		Les risques et les pertes stables	Éradication mondiale de la peste des petits ruminants est sur le point de commencer → maladie , nous l'espérons disparaître du Sahel et de l'Afrique en une à deux décennies → pas plus de pertes
		Chaud/Sec			Foyers de PPR plus fréquentes → Pertes plus elevées (effet de modulation de l'état immunitaire du cheptel et de la virulence de la souche	
Clavelée (V)	**Conditions environnementales**: Augmentation de l'humidité entraine des taux de reproduction élevés et de plus longues périodes d'activité des insectes	Chaud/humide	Déplacement des Insectes infectés par le vent peut participe à la dissémination du virus		Accroissement de la fréquence de propagation des insectes piqueurs infectés →risque accru d'épidémies	

	piqueurs → population croissante des insectes piqueurs infectés; Augmentation de l'aridité a l'effet inverse ; la vitesse du vent est importante pour la propagation des insectes infectés **Gestion du bétail et occupation de l'espace** : Pas d'effet significatif	Chaud/Sec	Réduction de la population d'insectes infectés → moins de dissemination		Possibilités réduites de propagation des insectes piqueurs infectés → moindre risque d'épidémie	
Ecthyma contagieux (V) **(Virus ORF) un Poxviridae**	**Conditions environnementales**: Augmentation de l'humidité entraine des taux de reproduction élevés et de plus longues périodes d'activité des insectes piqueurs → population croissante des insectes piqueurs infectés; Augmentation de l'aridité a l'effet inverse ; la vitesse du vent est importante pour la propagation des insectes infectés Le couple humidité-chaleur ne lui est pas défavorable. **Gestion du bétail et occupation de l'espace** : Sous aride, transmission plus probablement due au fait des contacts beaucoup plus fréquents des troupeaux au niveau des points d'eau / sur les pâturages excessifs et dissémination de la maladie sur de longue distance avec la transhumance des troupeaux de petits ruminants:	Chaud/humide		Déplacement d' animaux infectés par la transhumance, prairies souillées peuvent participer à la dissémination du virus	Stabilité endémique dans les zones nouvellement infectées ne sont pas encore établies →risque accru de maladie et pertes plus élevées(accroissement de la morbidité	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
Parasitisme gastro-intestinal (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation de la durée de vie et activité des larves infectantes dans les pâturages → parasitisme plus important; En cas d'aridité, réduction de	Chaud/humide	Pas de changement - mais la période de transmission longue et plus forte augmente la densité de larves infestantes dans les pâturages		Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque de dissémination plus forte → infestation d'un grand nombre d'animaux	

	l'importance du parasitisme **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux augmente la dissémination des parasites en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/Sec	Pas de changement - mais la période de transmission plus courte et plus faible réduit la densité de larves infestantes dans les pâturages	Charge endoparasite plus faible → augmentation des performances de production et diminution de la mortalité et de morbidité
Pulicose (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important; En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains	Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,
		Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible→ augmentation des performances de production et diminution de la mortalité et de morbidité
Gale (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important; En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains	Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,
		Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible → augmentation des performances de production et diminution de la mortalité et de morbidité

2. Maladies à transmission vectorielle

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long-terme
Trypanosomose (P)	**Conditions environnementales:** Conditions humides sont propices au développement, à la reproduction et à l'alimentation des tsé-tsé → infection trypanosommienne du bétail plus fréquente, une aridité accrue peut conduire à la diminution des vecteurs biologiques (Tse Tse) et à l'émergence de vecteurs mécaniques (Stomoxes et Tabanides) qui peuvent conduire à une transmission sporadique des trypanosomes. **Gestion du bétail et occupation de l'espace :** Le déplacement des troupeaux vers les zones infestées de Tse Tse augmente le risque. Tandis que les animaux en stabulation sont moins exposés au risque trypanosomienne	Chaud/humide	Augmentation des densités glossiniennes	Amélioration de l'habitat des glossines et augmentation des densités glossiniennes.	Forte pression glossinienne → Pertes élevées	En zone d'enzootie → transmission continue mais pertes moindres, En zone nouvellement infectée → pertes très importantes
		Chaud/Sec	Diminution des vecteurs biologiques et transmission sporadique assurée par les vecteurs mécaniques → incidence trypanosomienne faible	Diminution progressive des vecteurs biologiques et mécaniques → incidence trypanosomienne nulle	Transmission biologique très réduite → Réduction des pertes dans les zones faiblement infestées de glossines	Disparition des vecteurs et de la maladie → Faibles pertes liées à la maladie
Fievre Vallée Rift (V)	**Conditions environnementales:** Fortes pluies avec inondations → intense reproduction des moustiques → forte interaction entre	Chaud/humide	Extension de la zone à risque de la FVR (effet des variations de la vitesse du vent?) Exemple extension du foyer de FVR du Désert de la Mauritanie en 2010 au nord du		Précipitations extrêmes et plus fréquentes raccourcissent les intervalles entre les flambées de FVR → poussées plus fréquentes et des pertes plus élevées	

	vecteur /hôte favorisant la transmission du virus →influence du vent sur de longues distances propagation des moustiques infectés **Les conditions arides sont défavorables au, développement du germe** **Gestion du bétail et occupation de l'espace** L'existence des périmètres irrigués favorise les conditions de transmission du virus chez le bétail de manière significative		Sénégal en 2013			
		Chaud/Sec	Zone réduite au risque de la FVR (effet des variations de la vitesse du vent?)	Zone endémique FVR foyers dans les zones d'irrigation, de nouvelles zones à risque	Précipitations extrêmes moins fréquentes prolongent les intervalles entre les flambées de FVR → moins de foyers et moins de pertes	En raison des changements dans les systèmes de production (cultures irriguées), les foyers de FVR se produisent indépendamment de la pluviométrie → avec des pertes plus élevées
Cowdriose (B)	**Conditions environnementales**: humidité accrue améliore la reproduction et l'activité d'alimentation des tiques → Exposition des bovins aux maladies transmises par les tiques; aridité accrue a un effet contraire; Températures élevées réduisent la survie des tiques. Dans des conditions chaudes et humides, taux de survie plus courte est compensé par un taux de reproduction élevé de tiques **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux entraine la prolifération des tiques en conditions chaudes et humides des zones infestées vers les zones non En conditions chaudes et arides entrainent la diminution de la	Chaud/humide	Eventail croissant de tiques infectées	Large éventail de tiques infectées	Pas de Stabilité endémique dans les zones nouvellement infectées → risque accru d'apparition de la maladie avec des pertes plus élevées	Stabilité endémique plus nette → risque de maladie réduite →diminution des pertes
		Chaud/Sec	Réduction du nombre de tiques infestées	Pourcentage de tiques infestées plus réduites	Réduction de l'exposition et le risque de maladie →diminution des pertes	instabilité endémique avec un risque plus accru d'apparition de cas graves sporadiques → augmentation des pertes

	prolifération des tiques et migration des zones infestées vers les zones non infestées					
Anaplasmose (B)	**Conditions environnementales**: humidité accrue améliore la reproduction et l'activité d'alimentation des tiques → Exposition des bovins aux maladies transmises par les tiques; aridité accrue a un effet contraire; Températures élevées réduisent la survie des tiques. Dans des conditions chaudes et humides, taux de survie plus courte est compensé par un taux de reproduction élevé de tiques **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux entraine la prolifération des tiques en conditions chaudes et humides des zones infestées vers les zones non infestées ; En conditions chaudes et arides entrainent la diminution de la prolifération des tiques et migration des zones infestées vers les zones non infestées	Chaud/humide	Eventail croissant de tiques infectées	Large éventail de tiques infectées	Pas de Stabilité endémique dans les zones nouvellement infectées → risque accru d'apparition de la maladie avec des pertes plus élevées	Stabilité endémique plus nette → risque de maladie réduite →diminution des pertes
		Chaud/Sec	Réduction du nombre de tiques infestées	Pourcentage de tiques infestées plus réduites	Réduction de l'exposition et le risque de maladie →diminution des pertes	instabilité endémique avec un risque plus accru d'apparition de cas graves sporadiques → augmentation des pertes

3. Maladies à transmission par hôte intermédiaire

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long-terme
Distomatose (P)	**Conditions environnementales**: Sous scénario de CC humide, développement des mollusques (hôte intermédiaire) qui excrètent les cercaires → augmentation du risque d'infestation au niveau des points d'eau → parasitisme plus important; En cas d'aridité, absence d'hôte intermédiaire → pas de transmission **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente l'infestation au niveau des points d'eau en conditions humides dans le système extensif (mobilité à grande échelle) mais absence d'infestation dans le système d'élevage moderne (mobilité réduite)	Chaud/humide	Période de transmission longue et plus forte prolifération des mollusques au niveau des points d'eau → forte émission de cercaires dans les points d'eau		Charge parasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque de d'émission de cercaires par hôte intermédiaire plus forte → infestation d'un grand nombre d'animaux	
		Chaud/Sec	Absence d'émission de cercaires → incidence nulle de la distomatose → pas de dissémination vers des zones indemnes		Absence de transmission → pas de cas nouveaux → augmentation des performances de production et diminution de la mortalité et de morbidité	

Schistosomiase (P) ***Schistosoma* sp.**	**Conditions environnementales**: Sous scénario de CC humide, développement des mollusques (hôte intermédiaire) qui excrètent les cercaires → augmentation du risque de d'infestation au niveau des points d'eau → parasitisme plus important; En cas d'aridité, absence d'hôte intermédiaire → pas de transmission **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente l'infestation au niveau des points d'eau en conditions humides dans le système extensif (mobilité à grande échelle) mais absence d'infestation dans le système d'élevage moderne (mobilité réduite)	Chaud/humide	Période de transmission longue et plus forte prolifération des mollusques au niveau des points d'eau → forte émission de cercaires dans les points d'eau	Charge parasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque de d'émission de cercaires par hôte intermédiaire plus forte → infestation d'un grand nombre d'animaux
		Chaud/Sec	Absence d'émission de cercaires → incidence nulle de la distomatose → pas de dissémination vers des zones indemnes	Absence de transmission → pas de cas nouveaux → augmentation des performances de production et diminution de la mortalité et de morbidité

Caprin

1. Maladies à transmission directe (animal, sol, végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
Pasteurellose (B) ***Pasteurella sp***	**Conditions environnementales:** Augmentation de l'humidité améliore la prolifération des pasteurelles →fréquences accrues et exposition plus régulière du bétail à la pasteurellose ; Aridité accrue a un effet opposé, les températures chaudes réduisent la survie des germes : les Pasteurelles étant très fragiles une fois en contact avec la chaleur **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride Les germes opportunistes sont retrouvés dans les voies respiratoires supérieures et leur	Chaud/humide	Nombre croissant de Pasteurelles	Nombre plus important de Pasteurelles	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre réduit de Pasteurelles	Nombre plusréduit de Pasteurelles qui ne supportent pas la chaleur	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes

	dévloppement est favorisé par l'état de stress liés aux déplacements du bétail pour l'obtention de meilleures conditions alimentaires					
Piétin (B) *Oculimacula yallundae*	**Conditions environnementales:** Augmentation de l'humidité améliore la prolifération des germes cibles →fréquences accrues et exposition plus régulière du bétail à *Oculimacula yallundae*, un champignon pathogène; Aridité accrue a un effet opposé, les températures chaudes ne sont pas favorable à la survie de ces champignons qui ne résistent pas à la chaleur . **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride (prolifération de ces champignons pathogènes)	Chaud/humide	Nombre croissant Champignons	Nombre plus croissant de champignons	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre réduit de champignons Gamme	Réduction du nombre de champignons	Réduction de l'état l'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie → pertes plus importantes
Ecthyma contagieux (V)	**Conditions environnementales:**	Chaud/humide				
	Gestion du bétail et occupation de l'espace	Chaud/Sec				

Peste des Petits ruminants (V)	**Conditions environnementales:** Conditions humides et l'ombre (température plus basse) de transmission de faveur de virus **Gestion du bétail et occupation de l'espace :** Sous aride, transmission plus probablement due au fait des contacts beaucoup plus fréquents des troupeaux au niveau des points d'eau / sur les pâturages excessifs et dissémination de la maladie sur de longue distance avec la transhumance des troupeaux de petits ruminants et des dromadaires :	Chaud/humide	Expansion spatiale possible sur vers la bassin de la méditerrannée et menace pour les pays au Sud de la méditerranée d' autant plus ; la PPR couvre déjà l'ensemble du Sahel – alors qu' historiquement était plus fréquents dans les zones sub-humid/humid Afrique de l'Ouest	Les risques et les pertes stables	Éradication mondiale de la peste des petits ruminants est sur le point de commencer ◊ maladie
		Chaud/Sec		Foyers de PPR plus fréquentes → pertes plus élevées (fonction de l'état immunitaire du cheptel et de la virulence de la souche !	
Teigne (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important; En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains	Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,	
		Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible → augmentation des performances de production et diminution de la mortalité et de morbidité	
Parasitose gastro-intestinal (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation de la durée de vie et activité des larves infestantes dans les pâturages → parasitisme plus important;	Chaud/humide	Pas de changement - mais la période de transmission longue et plus forte augmente la densité de larves infestantes dans les pâturages	Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque de dissémination plus forte → infestation d'un grand nombre d'animaux	

	En cas d'aridité, réduction de l'importance du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente la dissémination des parasites en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/Sec	Pas de changement - mais la période de transmission plus courte et plus faible réduit la densité de larves infestantes dans les pâturages	Charge endoparasite plus faible → augmentation des performances de production et diminution de la mortalité et de morbidité
Gale (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important; En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains	Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,
		Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible → augmentation des performances de production et diminution de la mortalité et de morbidité

2. Maladies à transmission vectorielle

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme		
Cowdriose (B)	**Conditions environnementales**: humidité accrue améliore la reproduction et l'activité d'alimentation des tiques → Exposition des bovins aux maladies transmises par les tiques; aridité accrue a un effet contraire; Températures élevées réduisent la survie des tiques. Dans des conditions chaudes et humides, taux de survie plus courte est compensé par un taux de reproduction élevé de tiques **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux entraine la prolifération des tiques en conditions chaudes et humides des zones infestées vers les zones non infestées.En conditions chaudes et arides entrainent la diminution de la prolifération des tiques et migration des zones infestées vers les zones non infestées	Chaud/humide	Eventail croissant de tiques infectées	Large éventail de tiques infectées	Pas de Stabilité endémique dans les zones nouvellement infectées → risque accru d'apparition de la maladie avec des pertes plus élevées	Stabilité endémique plus nette → risque de maladie réduite →diminution des pertes
		Chaud/Sec	Réduction du nombre de tiques infestées	Pourcentage de tiques infestées plus réduites	Réduction de l'exposition et le risque de maladie →diminution des pertes	instabilité endémique avec un risque plus accru d'apparition de cas graves sporadiques → augmentation des pertes

Anaplasmose (B)	**Conditions environnementales**: humidité accrue améliore la reproduction et l'activité d'alimentation des tiques → Exposition des bovins aux maladies transmises par les tiques; aridité accrue a un effet contraire; Températures élevées réduisent la survie des tiques. Dans des conditions chaudes et humides, taux de survie plus courte est compensé par un taux de reproduction élevé de tiques **Gestion du bétail et occupation de l'espace :** La mobilité des troupeaux entraine la prolifération des tiques en conditions chaudes et humides des zones infestées vers les zones non En conditions chaudes et arides entrainent la diminution de la prolifération des tiques et migration des zones infestées vers les zones non infestées	Chaud/humide	Eventail croissant de tiques infectées	Large éventail de tiques infectées	Pas de stabilité endémique dans les zones nouvellement infectées → risque accru d'apparition de la maladie avec des pertes plus élevées	Stabilité endémique plus nette → risque de maladie réduite →diminution des pertes
		Chaud/Sec	Réduction du nombre de tiques infestées	Pourcentage de tiques infestées plus réduites	Réduction de l'exposition et le risque de maladie →diminution des pertes	instabilité endémique avec un risque plus accru d'apparition de cas graves sporadiques → augmentation des pertes

Equins

1. Maladies à transmission directe (animal, sol, végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	**Long-terme**	**Court terme**	**Long terme**
		Chaud/Sec	Nombre réduit de germes	Nombre beaucoup plus réduit de germes.	Réduction de l'état dexposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes
Botulisme (B) *Clostridium botulinum*	**Conditions environnementales:** • augmentation de l'humidité améliore la prolifération des formes végétatives de *Clostridium botulinum* →fréquences accrues et exposition plus régulière du bétail à *Clostridium botulinum;* aridité accrue a un effet semblable par la	Chaud/humide	Nombre croissant de germes	Nombre plus important de germes	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre croissant de formes sporulantes	Nombre beaucoup plus important suite à la multiplication des formes sporulantes.	Réduction de l'état d'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes

	multiplication des formes sporulantes **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride (prolifération des formes sporulantes					
Lymphangite épizootique (B) *Streptoccocus βhémolytique, Streptococcus sp..*	**Conditions environnementales:** Augmentation de l'humidité améliore la prolifération des germes cibles →fréquences accrues et exposition plus régulière du bétail à *Streptoccocus βhémolytiques;* Aridité accrue a un effet opposé avec une réduction de la survie des Streptocoques **Gestion du bétail et occupation de l'espace** migration plus fréquente dans les zones non infectées et dans les zones endémiques sous aride (prolifération des Streptocoques pathogènes)	Chaud/humide	Nombre croissant de germes	Nombre plus important de germes	Stabilité endémique dans les zones nouvellement infectées →risque accru de maladie et pertes plus élevées	Stabilité endémique bien installée dans les zones nouvellement infectées→diminution du risque avec des pertes plus faibles
		Chaud/Sec	Nombre réduit de germesGamme	Nombre plus réduit de germes	Réduction de l'état d'exposition et le risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes
Gale (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation du parasitisme plus important;	Chaud/humide	Faible dissémination car réduction du contact entre animaux malades et sains		Charge parasitaire forte → diminution des performances de production et augmentation de la mortalité et de morbidité,	

	En cas d'aridité, réduction du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente le contact entre animaux parasités et animaux sains en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/Sec	Forte dissémination spatiale	Charge parasitaire faible → augmentation des performances de production et diminution de la mortalité et de morbidité
Parasitisme gastro-intestinal (P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation de la durée de vie et activité des larves infectantes dans les pâturages → parasitisme plus important; En cas d'aridité, réduction de l'importance du parasitisme **Gestion du bétail et occupation de l'espace** La mobilité des troupeaux augmente la dissémination des parasites en conditions humides dans le système extensif (mobilité à grande échelle) comme dans le système moderne (mobilité réduite)	Chaud/humide	Pas de changement - mais la période de transmission longue et plus forte augmente la densité de larves infestantes dans les pâturages	Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque de dissémination plus forte → infestation d'un grand nombre d'animaux
		Chaud/Sec	Pas de changement - mais la période de transmission plus courte et plus faible réduit la densité de larves infestantes dans les pâturages	Charge endoparasite plus faible → augmentation des performances de production et diminution de la mortalité et de morbidité

2. Maladies à transmission vectorielle

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	**Long-terme**		
Trypanosomose (P)	**Conditions environnementales:** Conditions humides sont propices au développement, à la reproduction et à l'alimentation des tsé-tsé → infection trypanosommienne du bétail plus fréquente, une aridité accrue peut conduire à la diminution des vecteurs biologiques (Tse Tse) et à l'émergence de vecteurs mécaniques (Stomoxes et Tabanides) qui peuvent conduire à une transmission sporadique des trypanosomes. **Gestion du bétail et occupation de l'espace :** Le déplacement des troupeaux vers les zones infestées de Tse Tse augmente le risque. Tandis que les animaux en stabulation sont moins exposés au risque trypanosomienne	Chaud/humide	Augmentation des densités glossiniennes	Amélioration de l'habitat des glossines et augmentation des densités glossiniennes.	Forte pression glossinienne → Pertes élevées	En zone d'enzootie → transmission continue mais pertes moindres, En zone nouvellement infectée → pertes très importantes
		Chaud/Sec	Diminution des vecteurs biologiques et transmission sporadique assurée par les vecteurs mécaniques → incidence trypanosomienne faible	Diminution progressive des vecteurs biologiques et mécaniques → incidence trypanosomienne nulle	Transmission biologique très réduite → Réduction des pertes dans les zones faiblement infestées de glossines	Disparition des vecteurs et de la maladie → Faibles pertes liées à la maladie
Peste équine (V) (Vrius de la Peste équine – Orbivirus) (Voir	**Conditions environnementales**: Fortes pluies → intense reproduction des Culicoïdes → forte interaction entre vecteur /hôte	Chaud/humide	Déplacement des Insectes infectés par le vent peut participe à la dissémination du virus		Accroissement de la fréquence de propagation des insectes piqueurs infectés →risque accru d'épidémies	

Rift)	favorisant la transmission du virus →influence du vent sur de longues distances à l'origine de la propagation des Culicoïdes infectés ; Les conditions arides sont défavorables au, développement du vecteur **Gestion du bétail et occupation de l'espace :** Le déplacement des Equidés infectés (lors des marchés hebdomadaires, des migrations de certains travailleurs) favorise la diffusion du virus					
		Chaud/Sec	Réduction de la population d'insectes infectées → moins de dissémination		Possibilités réduites de propagation des insectes piqueurs infectés → moindre risque d'épidémie	
Habronémose (P) (*Habronema* sp)	**Conditions environnementales:** Conditions humides sont propices au développement, à la reproduction des mouches hôtes intermédiaires (stomoxes et mouches domestiques) → infestation des équidés plus fréquente. Une aridité accrue peut conduire à la diminution des hôtes intermédiaires → une infestation sporadique. **Gestion du bétail et occupation de l'espace :** Le déplacement des équidés vers les zones non infestées de mouches réduit le risque. Tandis que les animaux en stabulation sont plus exposés au risque	Chaud/humide	Augmentation des densités de mouches	Prolifération des gîtes de reproduction des mouches et augmentation des densités.	Forte pression de mouches →Morbidité accrue	infestation continue avec ,forte morbidité
		Chaud/Sec	Diminution des densités de mouches et infestation sporadique → incidence faible	Diminution progressive des hôtes intermédiaires → incidence quasi nulle	Infestation très réduite → Réduction de la morbidité dans les zones faiblement infestées de mouches	Disparition des hôtes intermédiaires et de la maladie → Faible morbidité liée à la maladie

Asins

1. Maladies à transmission directe (animal, sol, végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
		Chaud/Sec	Nombre réduit de germes	Nombre plus réduit de germesEventail	Réduction de l'étatd'exposition et du risque de maladie → diminution des pertes	Arrêt de l'exposition et du risque de maladie →plus de pertes

2. Maladies à transmission vectorielle

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme		
Trypanosomose (P)	**Conditions environnementales:** Conditions humides sont propices au développement, à la reproduction et à l'alimentation des tsé-tsé → infection trypanosommienne du bétail plus fréquente, une aridité accrue peut conduire à la diminution des vecteurs biologiques (Tse Tse) et à l'émergence de vecteurs mécaniques (Stomoxes et Tabanides) qui peuvent conduire à une transmission sporadique des trypanosomes. **Gestion du bétail et occupation de l'espace** Le déplacement des troupeaux vers les zones infestées de Tse Tse augmente le risque. Tandis que les animaux en stabulation sont moins exposés au risque trypanosomienne	Chaud/humide	Augmentation des densités glossiniennes	Amélioration de l'habitat des glossines et augmentation des densités glossiniennes.	Forte pression glossinienne →Pertes élevées	En zone d'enzootie → transmission continue mais pertes moindres, En zone nouvellement infectée → pertes très importantes
		Chaud/Sec	Diminution des vecteurs biologiques et transmission sporadique assurée par les vecteurs mécaniques → incidence trypanosomienne faible	Diminution progressive des vecteurs biologiques et mécaniques → incidence trypanosomienne nulle	Transmission biologique très réduite → Réduction des pertes dans les zones faiblement infestées de glossines	Disparition des vecteurs et de la maladie → Faibles pertes liées à la maladie

Volaille

1. Maladies à transmission directe (animal, sol,végétal, etc.)

Nom de la maladie	Facteurs affectant les maladies vectorielles et la transmission des agents pathogènes	Scénario de changement climatique	Impacts attendus du changement climatique			
			Sur la répartition spatiale de l'infection		Sur le risque épidémiologique et les pertes liées aux maladies	
			Court terme	Long-terme	Court terme	Long terme
Maladie de Newcastle (V) (Voir PPR)	**Conditions environnementales:** Conditions humides et l'ombre (température plus basse) de transmission de faveur de virus **Gestion du bétail et occupation de l'espace :** Sous aride, transmission plus probablement due au fait que contacts des vollailles au niveau de la basse cour au niveau des marchés hebdomadaires avec l' achat de vollaille malades	Chaud/humide	Pas expansion spatiale possible ; Le virus de la maladie de New Castle virus couvre actuellement tout le Sahel -		Les risques et les pertes stables	Contrôle permanent de la maladie de New Castle par une bonne vaccination → pas plus de pertes
		Chaud/Sec			Foyers de M. Newcastle plus fréquentes → Pertes plus élevées (effet de modulation de l'état immunitaire du cheptel et de la virulence de la souche	
Variole (V) (Voir Clavelée	**Conditions environnementales**: Augmentation de l'humidité entraine des taux de reproduction élevés et de plus longues périodes d'activité des insectes	Chaud/humide	Déplacement des Insectes infectés par le vent peut participe à la dissémination du virus		Accroissement de la fréquence de propagation des insectes piqueurs infectés →risque accru d'épidémies	

Ovins) Virus de la clavelée - **Poxvirus**	piqueurs → population croissante des insectes piqueurs infectés; Augmentation de l'aridité a l'effet inverse ; la vitesse du vent est importante pour la propagation des insectes infectés **Gestion du bétail et occupation de l'espace** : Pas d'effet significatif	Chaud/Sec	Réduction de la population d'insectes infectés → moins de dissemination	Possibilités réduites de propagation des insectes piqueurs infectés → moindre risque d'épidémie
Parasitisme gastro-intestinal(P)	**Conditions environnementales**: Sous scénario de CC humide, augmentation de la durée de vie et activité des larves infectantes dans la basse cour → parasitisme plus important. En cas d'aridité, réduction de l'importance du parasitisme **Gestion du bétail et occupation de l'espace** Le déplacement de la volaille augmente la dissémination des parasites en conditions humides dans le système d'aviculture traditionnelle	Chaud/humide	Pas de changement - mais la période de transmission longue et plus forte augmente la densité de larves infestantes.	Charge endoparasitaire plus forte → diminution des performances de production et augmentation de la mortalité et de morbidité, Risque élevé de dissémination → infestation d'un grand nombre de sujets
		Chaud/Sec	Pas de changement - mais la période de transmission plus courte et plus faible réduit la densité de larves infestantes.	Charge endoparasitaire plus faible → augmentation des performances de production et diminution de la mortalité et de morbidité

Conclusions

En relation avec les services vétérinaires de Matam, Kanel, Bakel et Tambacounda, il a été possible d'établir la liste des pathologies de ces départements. Et en se basant sur les prévisions les plus probables en terme d'évolution du climat dans les années futures et sur les données de littérature, il a été possible de déterminer les modifications attendues en terme d'importance, de répartition et de virulence des principales affections au niveau des différentes espèces animales.

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ANNEX K. MARKET ACCESS (FRENCH)

ARCC / SENEGAL:

ANALYSE DE L'ACCES AUX MARCHES ET DES IMPACTS POTENTIELS DU CHANGEMENT CLIMATIQUE POUR LES PERIODES 2030 ET 2050

FINAL REPORT

Évaluation de la vulnérabilité au changement climatique et de l'analyse des options d'adaptation au Sénégal Oriental

Préparé par by:

Mars 2014

ENGLISH SUMMARY

Households in the study zone survive on the products of their two main agricultural activities: crop farming and raising livestock. A persistent deficit in grain production creates the region's strong dependence on markets. As a result of this dependence, markets play a fundamental role in household food security and strategies to adapt to climate variability, extremes, and change. Analysis of access to markets can, therefore, contribute to the description of the vulnerability and resilience of local populations.

The purpose of this study is to conduct a spatial analysis of market access and the expected impacts of climate change on this access for the years 2030 and 2050. This work is based on a review of the existing literature on the issue and on the use of Geographic Information Systems, including spatial analysis tools such as ESRI's Arcview and ArcGIS systems.

The analysis of markets was based on two primary criteria: the *availability* of products to be bought and sold and *accessibility* to these products based upon spatial factors such as the physical distance to markets, transportation networks, topography, and morphopedology (soil mapping). The study reviews market conditions in the departments of Matam, Kanel, Bakel and Goudiry. It describes the products marketed and the trade flows of those products, while also defining constraints related to access to markets. It discusses the potential impact of climate change on markets access, taking into account projected changes in rainfall and temperature.

Poor infrastructure exacerbates the impact of institutional constraints and slumps in economic activity, even more so in times of adverse weather (heavy rainfall, extreme temperatures, etc.). It aggravates conditions of vulnerability through loss of sales revenue and ruptures in food stocks. This study maps a composite index of the physical attributes affecting market access, thus describing one element of vulnerability in the study zone. The spatial analysis of rainfall and temperature projections for 2030 and 2050 are also considered.

The results of this study indicate that an understanding of the impact of market factors should play a substantial role in determining policy related to the region's capacity to adapt to climate change. Measures that may be effective include improving the physical infrastructure of markets; improving their spatial distribution; improving the density and the condition of road networks; taking account of climatic variability and extreme events in infrastructure design and construction; developing the adaptive capacity of local communities and production systems; and establishing early warning systems and procedures.

I - INTRODUCTION

A. Contexte

En Afrique subsaharienne, l'insécurité alimentaire constitue de plus en plus une menace dans un contexte d'insuffisance de l'offre, liée à l'accroissement de la population mondiale induisant une augmentation de la demande mais aussi, aux changements climatiques qui se traduisent par des sècheresses récurrentes dans des régions gros producteurs de céréales (Australie, USA) ayant pour effet de réduire l'offre et les stocks. Ce qui a induit une forte hausse des prix. Le Sénégal qui n'échappe pas à cette situation, enregistre parallèlement une faible croissance du secteur agricole avec un déficit céréalier persistant rendant les ménages fortement dépendants des marchés. En effet, d'après les résultats de l'analyse globale de la vulnérabilité et de la sécurité alimentaire (AGVSAN-2010), 85% des ménages ruraux sénégalais dépendent des marchés. Du fait d'une agriculture essentiellement pluviale, les perturbations climatiques risquent de compromettre les efforts de lutte contre la pauvreté et l'objectif d'atteindre l'autosuffisance alimentaire. Depuis le début des années 60, le déficit pluviométrique (d'environ 35 à 45% au Nord et de 20 à 25% au Sud), l'irrégularité inter et intra annuelle des précipitations (avec un raccourcissement de la durée de la saison des pluies et des pauses pluviométriques prolongées) et la baisse de fertilité des sols liée à la pression foncière et aux mauvaises pratiques agricoles, se sont traduits par une baisse de la production agricole et de la production primaire des pâturages en quantité comme en qualité. Cette situation fragilise les ménages ruraux vivant essentiellement de l'agriculture et/ou de l'élevage. C'est le cas dans la zone d'étude du projet « Évaluation de la vulnérabilité au changement climatique et de l'analyse des options d'adaptation au Sénégal Oriental ». Cette zone correspond aux régions de Matam et de Tambacounda choisies en raison du niveau élevé d'insécurité alimentaire.

Au Sénégal, les marchés, et en particulier les marchés ruraux, jouent un rôle important dans la sécurité alimentaire des ménages. Ils contribuent aux économies familiales comme source de revenus (vente de la production agricole, du bétail et des produits de cueillette) et pour l'achat de produits alimentaires et d'intrants de production. Durant les périodes de soudure les ménages pauvres qui ne peuvent pas couvrir leurs besoins en céréales s'adonnent à la vente des petits ruminants et à la cueillette des fruits sauvages qu'ils écoulent dans les marchés pour se faire des revenus. Le marché devient donc incontournable pour la sécurité alimentaire des ménages. L'accès au marché est cependant tributaire de plusieurs facteurs comme les conditions de transport des produits notamment l'existence et la qualité des infrastructures routières, la distance physique au marché, la fréquence d'ouverture du marché, la disponibilité du produit ou encore le niveau et la variabilité du prix par rapport aux revenus des ménages.

L'accès au marché constitue ainsi un élément influant de la capacité d'adaptation des ménages dans le contexte du changement climatique. L'inaccessibilité physique est une caractéristique de l'insécurité alimentaire rurale car elle entraine l'interruption des chaînes d'approvisionnement alimentaire. En plus des retombées sur la production alimentaire, le changement climatique engendre des phénomènes climatiques extrêmes tels que les inondations, les vents forts, la hausse des températures. Ces derniers peuvent endommager les infrastructures de transport très souvent en état de détérioration suite au manque d'entretien et de maintenance. L'analyse de l'accès aux marchés peut donc contribuer à la détermination du seuil de vulnérabilité et de résilience des populations locales.

Dans le cadre de cette étude ***Marchés et Vulnérabilité*** le CSE est chargé du volet analyse spatiale de l'accès aux marchés et des impacts attendus des changements climatiques sur cet

accès pour les périodes 2030 et 2050. Ce travail repose sur l'utilisation des Systèmes d'Information Géographique notamment l'outil ***analyse spatiale*** disponible avec ESRI Arcview ou ArcGIS, qui offre la possibilité de combiner des jeux de données de formats différents, de modéliser ces croisements d'informations et de traiter les résultats suivant les hypothèses de recherche qu'on se fixe.

B. Objectif

L'objectif de cette étude est d'évaluer à l'aide des SIG la vulnérabilité des ménages en relation avec l'accès au marché en tenant compte des impacts potentiels des changements climatiques sur le milieu et sur les systèmes de production au cours des périodes 2030 et 2050.

Les objectifs spécifiques consistent à faire :

- une analyse de la typologie et du maillage des marchés ;
- une analyse de l'accès physique (distance) au marché et aux voies de communication;
- une identification des opportunités et des contraintes de l'accès au marché;
- une analyse des impacts potentiels du changement climatique sur l'accès au marché dans les périodes 2030 et 2050.

C. Méthodologie

Cette étude de l'accès aux marchés dans le Sénégal Oriental est basée essentiellement sur deux approches: la première se fonde sur une revue de la littérature et la seconde sur l'utilisation des SIG pour conduire une analyse spatiale.

Revue de la Littérature

Cette revue se fonde sur un examen de la littérature relative aux marchés et aux infrastructures de transport connexes, à leur accessibilité et à l'impact des changements climatiques sur ces infrastructures. Elle permet d'aboutir à une caractérisation des marchés (type, fonction, produits commercialisés, accès). Les informations secondaires collectées proviennent principalement de diverses sources notamment des études faites par la communauté scientifique nationale et internationale, les différents ministères et agences du Sénégal (Ministère de l'Environnement et de la Protection de la Nature, Agence Nationale de la Statistique et de la Démographie (ANSD), et les organisations des Nations Unies telles que la FAO et le PNUD.

Cartographie

Elle se fera en deux phases : l'élaboration des variables cartographiques pour caractériser les conditions physiques de la zone d'étude et la combinaison des variables pertinentes pour conduire l'analyse des facteurs spatiaux.

Elaboration des produits cartographiques de base

La première étape de ce travail consiste à la collecte de l'information de base devant servir à l'analyse spatiale de l'accès au marché. La base de données du CSE est mise à contribution pour sélectionner l'information disponible sur la zone du projet (entités administratives, pédologiques, hydrographiques, topographiques, l'occupation du sol etc.). En cas de besoin la base de données sera complétée par les informations issues de la littérature.

Pour la projection 2030-2050, les résultats des analyses de l'étude sur la modélisation des ressources pastorales serviront de base pour évaluer l'impact du changement climatique sur l'accès au marché.

Ces données multi sources doivent être standardisées et hiérarchisées (données ponctuelle, linéaire, polygonale et raster) dans une Géodatabase. Les différentes couches informationnelles permettront alors d'élaborer des cartes thématiques de la zone d'étude. Les données ponctuelles (topographie, pluviométrie et température) seront interpolées sur l'étendue de la zone d'étude.

Elaboration des hypothèses d'accessibilité du marché

L'étude de marché est envisagée en se basant sur deux principaux critères :

- la disponibilité du produit à écouler ou à acquérir et
- l'accessibilité (disponibilité et qualité de l'infrastructure physique -marché et voie d'accès)

L'accessibilité dépend de plusieurs facteurs, dont :

- la **distance physique aux marchés** : l'enclavement des localités situées dans la zone d'étude et la distance physique aux marchés peuvent concourir à l'insécurité alimentaire en rendant l'approvisionnement et l'écoulement de la production difficiles. Pour trouver les localités proches des marchés et des voies de communication qui y mènent, on calcule à l'aide du SIG des zones de proximité (appelées zones tampons ou buffers). Pour cela, les marchés sont d'abord bufferisées à l'aide de la commande ***Create buffers***, de ArcView. Dans les zones tampons créées tout autour, la distance augmentent avec l'éloignement suivant un pas défini par l'utilisateur du système.
- ***les voies de communication*** : elles jouent un rôle important dans le cadre du développement socio-économique. En effet l'absence et le mauvais état des voies d'accès peuvent influer négativement sur le secteur commercial. L'existence, l'état (qualité/praticabilité), le type d'infrastructure de transport et la distance physique, conditionnent l'approvisionnement et l'écoulement des produits qui font l'objet de transaction commerciale. L'opération précédente (*bufferisation*) est répétée en ciblant les voies de communication. Cependant, l'existence physique d'une voie de communication ne suffit pas comme critère pour apprécier l'accès au marché. Et lorsqu'elle existe, pour apprécier l'accessibilité, la distance physique localité - voie de communication, doit être complétée par l'information sur le type d'infrastructure routière et sur sa praticabilité.
- ***la topographie*** : la prise en compte du relief est importante car il peut représenter une contrainte (cas de localités situées dans un bas-fonds susceptible d'être inondée durant la saison des pluies avec comme incidence une rupture des voies de communication qui le traversent représentant une contrainte pour la mobilité des populations). Pour avoir une idée de la topographie de la zone d'étude l'outil « SurfacingToll » de Erdas imagine aidera à créer un modèle numérique de terrain. Les courbes de niveau et les points côtés numérisés à partir de la feuille topographique à l'échelle du 200 000 couvrant la zone d'étude, servent d'input. Le modèle numérique permettra de sélectionner les localités situées en basse altitude et donc susceptibles d'être inondées en cas de fortes pluies et sujettes à l'enclavement.
- ***l'hydrographie*** : Le fleuve Sénégal borde la zone d'étude sur toute sa partie orientale et la moitié septentrionale. Les nombreuses vallées constituent un réseau hydrographique chevelu ; elles sont fossiles pour la plupart ; s'y ajoutent de nombreuses mares naturelles

non permanentes. Ces points d'eau remplis durant l'hivernage peuvent impacter la praticabilité des voies de communication et détruire l'infrastructure à travers des phénomènes d'érosion et d'inondation. Au cours de la saison des pluies ils peuvent ainsi occasionner l'enclavement des localités.

- ***la pédologie*** : la pédologie est importante dans cette étude, car, compte tenu de la texture des sols, les zones considérées (y compris les voies d'accès) seront plus ou moins fragiles, érodables et inondables. En particulier, les sols hydromorphes, halomorphes, et argileux de par leur capacité élevée en rétention d'eau, peuvent freiner la mobilité des populations et constituer une entrave à l'accès aux marchés.

Ces facteurs physiques concourent à un ralentissement exacerbé de l'activité économique et sociale notamment en cas de conditions climatiques défavorables (forte pluviosité, températures extrêmes, etc.). Ils peuvent alors exacerber la précarité des ménages à travers la perte des revenus tirés des marchés et la rupture de stocks alimentaires compromettant l'état nutritionnel des populations.

Outre l'accessibilité au marché, la disponibilité des produits du terroir (agricoles, pastoraux, forestiers) est importante pour la survie des ménages. Le changement climatique a occasionné la dégradation des ressources naturelles et pourrait si la tendance évolutive négative se poursuit provoquer des crises économiques et humanitaires. Il convient de mettre en place des stratégies adaptatives pour aider les ménages à faire face aux effets des aléas climatiques.

La cartographie de l'occupation /utilisation du sol permet de cerner l'évolution de la couverture végétale et aide à la localisation des zones qui abritent d'importantes ressources. Toutefois pour connaître l'utilisation des ressources, l'information cartographique doit être complétée par des inventaires et des enquêtes de terrain. Par exemple les zones agricoles peuvent être identifiées sur les images mais les différentes spéculations ne pourront pas être déterminées. Il en est de même pour la couverture végétale, la connaissance de la composition floristique aurait permis d'identifier les espèces disparues ou rares de même que leurs sous-produits utilisés par les ménages pour l'autoconsommation ou la vente. C'est le cas des produits de cueillette qui occupent une part importante des revenus des ménages.

Analyse spatiale

Les couches d'information précédemment élaborées seront exploitées et combinées pour faire une analyse multicritères tenant compte de : la distance physique au marché, aux voies de communication, de l'altitude, de la nature des sols. Concernant l'hydrographie en raison de la non disponibilité d'une couche thématique permettant de sélectionner les bassins versants des principaux cours d'eau, la couche pédologie sera utilisée pour sélectionner les zones inondables en se basant sur la nature du sol.

Pour faire l'analyse multicritère toutes les variables seront classées dans une échelle commune. Un indice composite d'accès sera élaboré en faisant la somme des indices élémentaires. La combinaison des informations permettra d'identifier le niveau de vulnérabilité des localités situées dans la zone d'étude.

II - PRESENTATION DE LA ZONE D'ETUDE

La zone d'étude comprend une zone nord et une zone sud (Figure 1). Elle est à cheval entre les régions de Matam au Nord (départements de Matam et Kanel) et de Tambacounda au Sud (départements de Goudiry et Bakel).

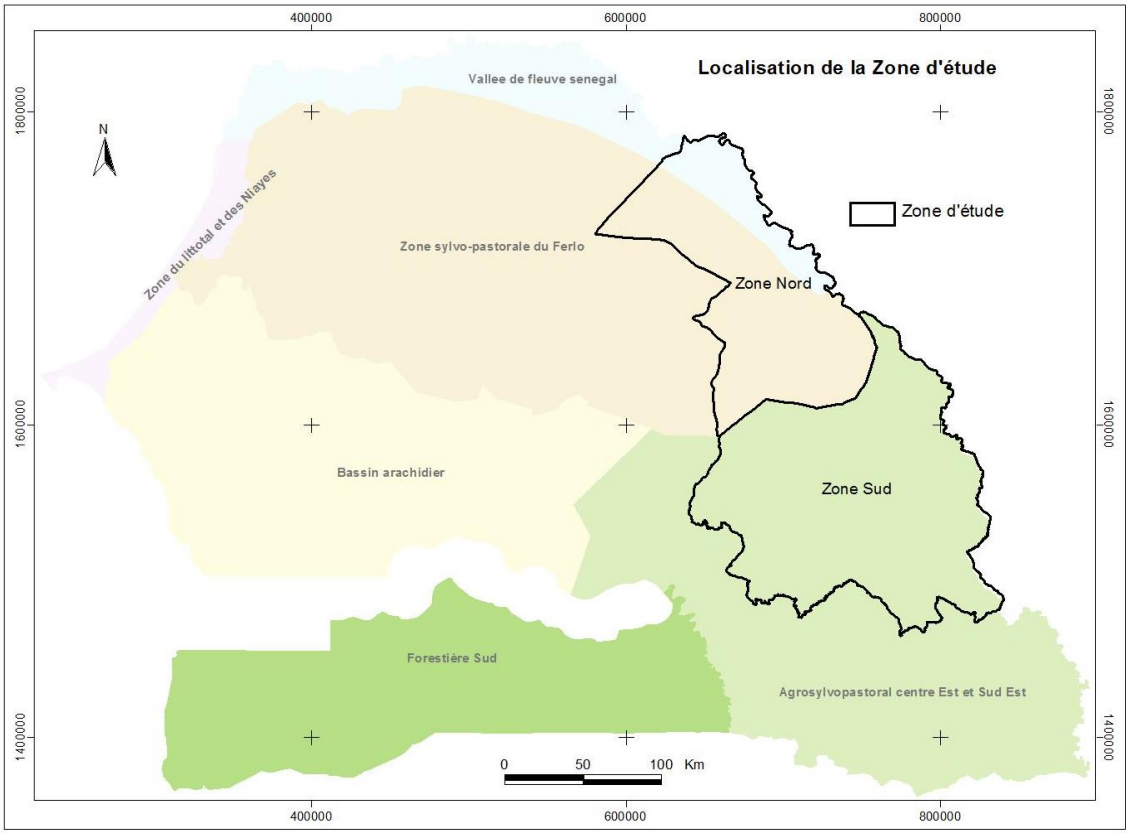

Figure 1: Localisation de la zone d'étude

2.1 La zone nord

2.1.1 Situation géographique et milieu physique

La région de Matam (figure 2) est située entre 14°20 et 16°10 de latitude Nord et entre 12°40 et 14°60 de longitude ouest. Elle couvre une superficie de 29.616 Km2. Le **relief**, caractérisé par une vaste plaine incisée de vallées, est relativement plat par rapport au reste du pays. La région compte trois départements: Matam, Kanel et Ranérou-ferlo. Seuls les deux premiers départements cités sont concernés par cette étude. Ils sont situés en zones sahélienne et soudano sahélienne, dans les zones éco-géographiques de la vallée du fleuve *Sénégal* et de la zone sylvo-pastorale du *Ferlo*. Le ***climat*,** de type sahélien continental, est caractérisé par une saison sèche, qui va de novembre à juin, et une saison des pluies, qui va de juillet à octobre.

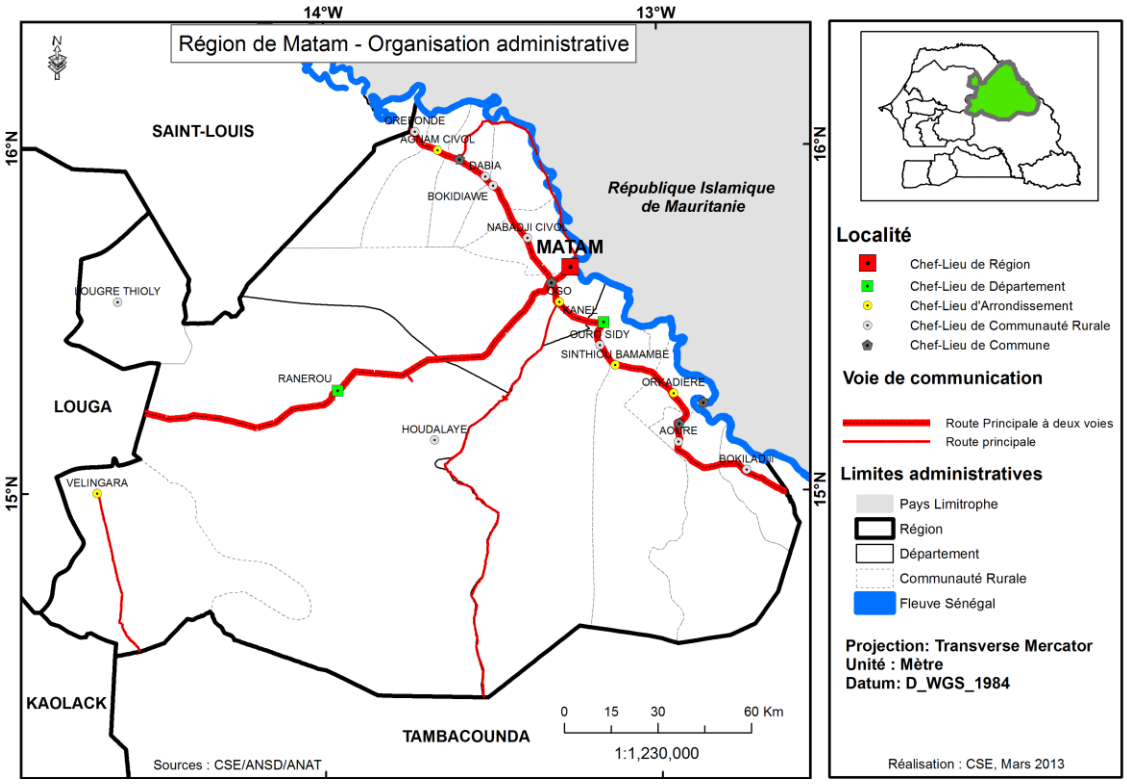

Figure 2: Carte administrative de Matam

La pluviométrie, marquée par une forte variabilité dans le temps et dans l'espace (figure 3), oscille entre les isohyètes 300 et 500 mm, avec des précipitations pouvant atteindre parfois 600 mm d'eau dans la partie sud. La tendance globale est à la baisse sur la période 1970-2000. **Les températures** moyennes sont très élevées aux mois d'avril, mai et juin, la température maximale moyenne est enregistrée à Matam (> 40°c).

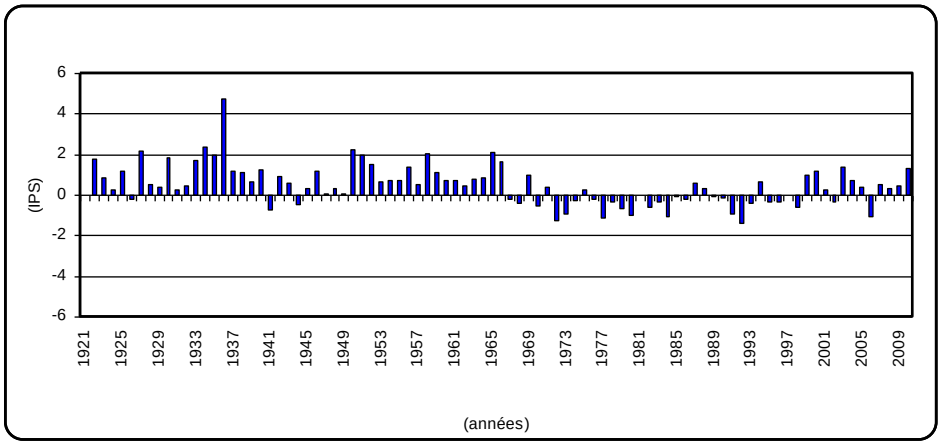

Figure 3: Anomalies pluviométriques (1921-2010) à Matam (Source : CSE)

La **végétation** est très diversifiée. Du Nord au Sud on distingue : la zone du *Walo* où l'espèce dominante est le gonakier (*Acacia nilotica* var *tomentosa*) associé à des épineux ; au niveau du

Diéri et du *Ferlo* on note une prédominance des épineux (*Balanites aegyptiaca*, *Acacia senegal*, etc.). Le tapis herbacé est dominé par les graminées annuelles[1].

L'exploitation de la carte PNAT montre les mêmes types de **sols** (figures 4 et 6) dans le nord et le sud de la zone d'étude à l'exception des sols bruns subarides formés sur les dunes ogoliennes qui sont caractéristiques de la partie nord.

- **les sols vertiques (ou vertisols)** sont formés sur du matériau argileux. Ils ont une teneur très élevée en argile). Ils occupent très souvent les vallées, les dépressions et les zones de bas de pentes des plateaux cuirassés. Ils sont très étendus dans la cuvette de décantation du fleuve Sénégal où ils coexistent avec les sols peu évolués. Ces zones sont toujours inondées pendant l'hivernage.
- **les sols hydromorphes** dont l'évolution est dominée par un excès d'eau. On les retrouve dans les vallées, terrasses, levées deltaïques, cuvettes, vasières, vallées inter dunaires, etc. Ils se distinguent par une texture sablo-argileuse à argileuse et une teneur en matière organique variant entre 2 à 15% (Stancioff et al, 1986). Les sols hydromorphes sont plus fréquents sur les versants et sur le lit mineur des vallées du *Sénégal* et de la *Falémé*. Ils correspondent aux alluvions diverses des zones inondables qui bordent la Gambie, la Falémé. Ce sont aussi des sols des zones basses ou planes renfermant de l'argile.
- **les sols ferrugineux tropicaux lessivés** sont rencontrés sur les plateaux, les buttes et les basses plaines. Ces sols sont principalement développés sur granites dans le Sénégal oriental. Les textures varient du sableux-argileux à l'argileux ; Les sols ferrugineux tropicaux à taches et concrétions se caractérisent par une richesse en sesquioxydes de fer individualisé repartis sur l'ensemble du profil ou très souvent accumulés dans des horizons inférieurs sous forme des tache ou des concrétions. Au Sénégal oriental, la fraction argileuse de ces sols est exclusivement constituée de kaolinite. Ils se développent sur les matériaux de colmatage des axes de drainage qui parsèment des vastes surfaces.
- **les sols peu évolués** : de faciès ferrugineux (Goudiry), le faciès brun eutrophe se développe sur des versants à pentes fortes des massifs de roches basiques et ultrabasiques, le faciès à hydromorphie de profondeur se trouve sur des bourrelets des berges de la Falémé. Ils se caractérisent par la présence des blocs de roches qui marquent un pavage de leurs surfaces. Comme les vertisols, leur composition minéralogique est marquée par une richesse en montmorillonite, dotée d'un haut pouvoir de rétention. Au Sénégal oriental ils sont formés sur du matériel argileux marno-calcaire. Leur teneur en argile est très élevée.
- **les sols halomorphes à alcalis** localisés dans les plaines le long de la *Falémé*, ont une origine pétrographique. Ils reposent sur d'anciennes surfaces témoins cuirassées, en association avec des sols hydromorphes et des vertisols.
- **les régosols (sols très peu évolués sur des matériaux tendres) et lithosols (sols squelettiques sur des matériaux durs)** constituent des sols peu évolués d'érosion caractéristiques des pentes continuellement soumises à ce phénomène[2].

2.1.2 Caractéristiques démographiques et socio-économiques

En 2010, la population de la région de Matam était estimée à 542 201 habitants plus de la moitié (51%) vivant dans le département de Matam soit 276 502 habitants et 38,7%, soit 209 621

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1 Conseil interministériel du 21 mars 2013, région de Matam, CSE, 2013

2 Rapport sur l'Etat de l'Environnement au Sénégal, CSE, édition 2013

habitants, dans le département de Kanel (ANSD, 2011). Ainsi, dans la zone nord les deux départements de Matam et Kanel totalisent 486 123 habitants sur une superficie de 14 558 km2 ce qui correspond à une densité de 33 habitants au km2. Les principaux revenus des ménages proviennent de l'agriculture, de l'élevage et des transferts d'argent issus de l'émigration.

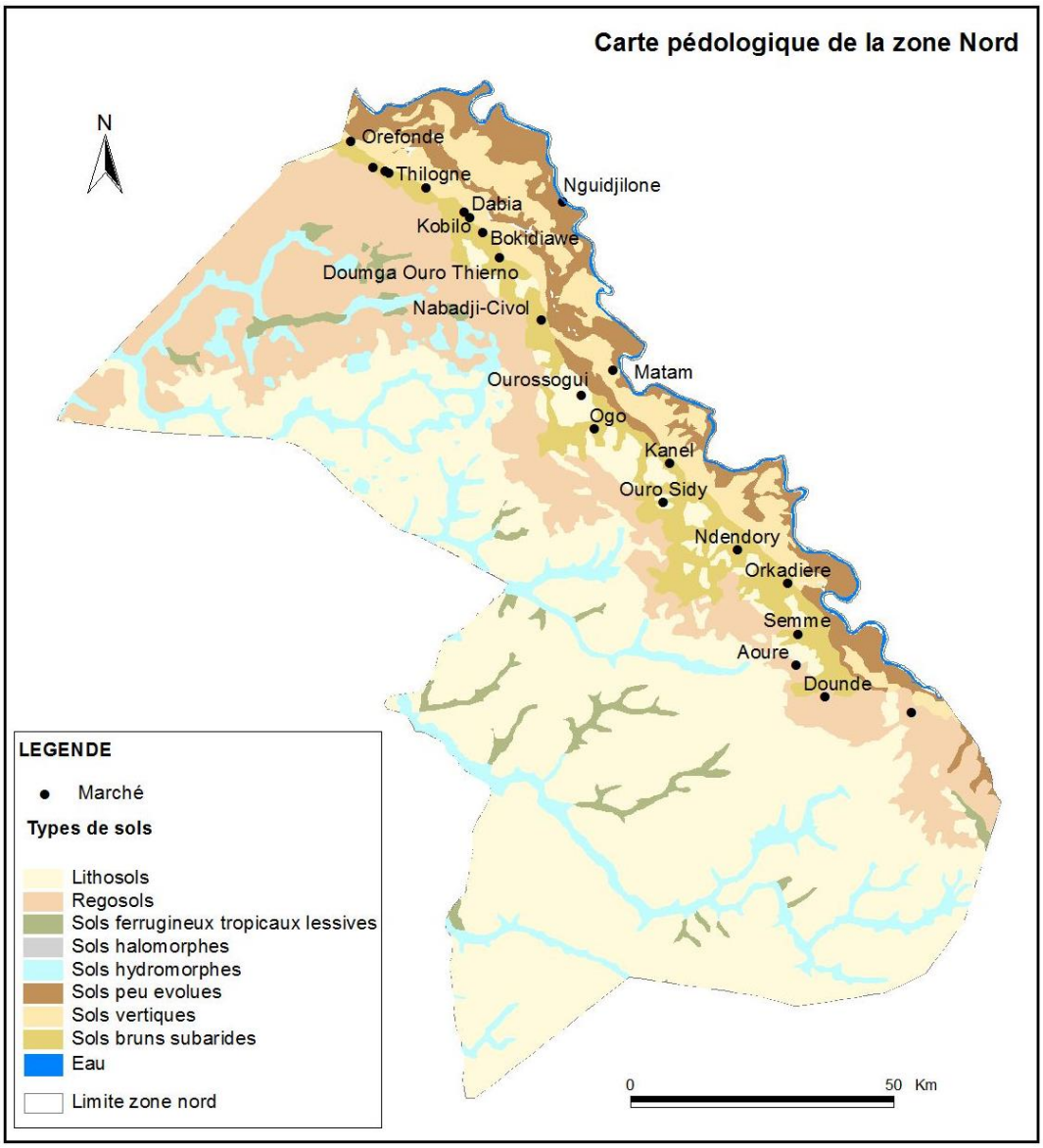

Figure 4: Carte pédologique de la zone nord

2.2 LA ZONE SUD

2.2.1 Situation géographique et milieu physique

La région de Tambacounda (figure 5), située à l'extrême est du Sénégal, justifiant ainsi l'appellation Sénégal oriental (Profil des Moyens d'Existence de la zone Agro-Sylvo-Pastorale, Département de Tambacounda, 2011) couvre une superficie de 42 706 km$^{2.}$

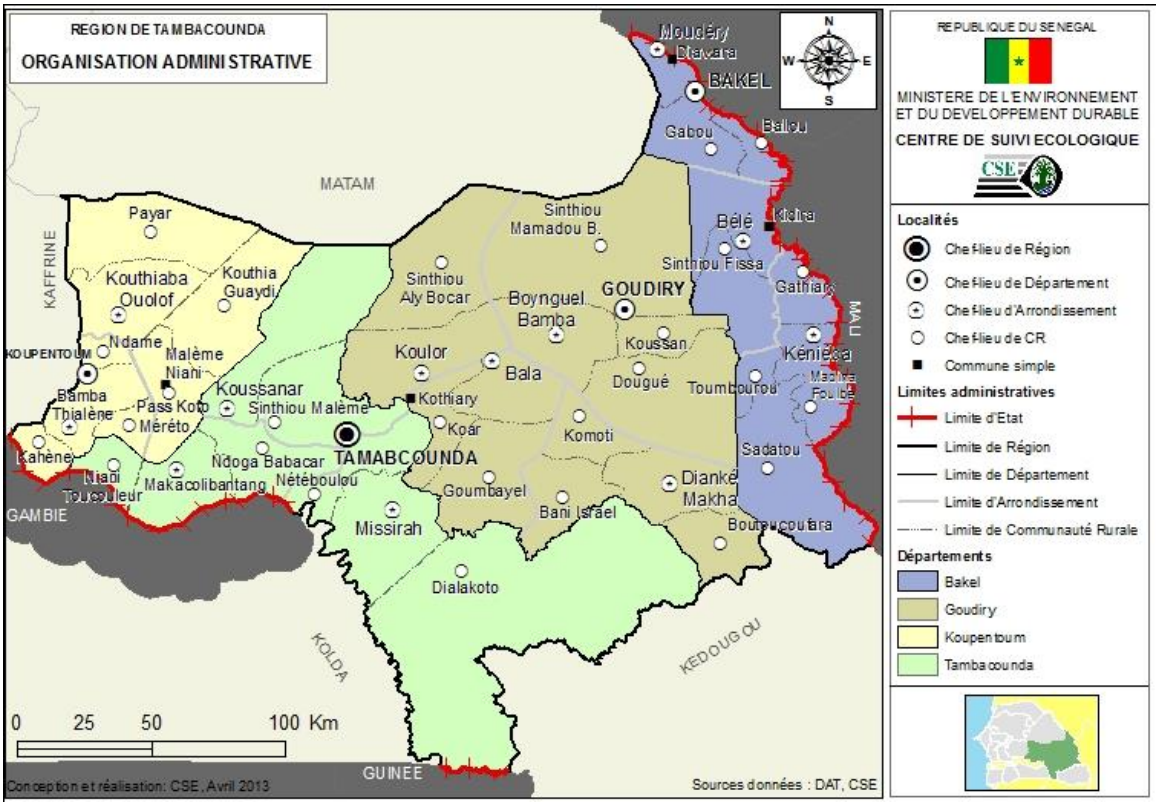

Figure 5: Carte administrative de Tambacounda

Elle est caractérisée par un **relief** plat entrecoupé par de légères dépressions. Elle est située entre les isohyètes 450 et 1200 mm et figure parmi les régions les plus pluvieuses du pays (ANDS, 2010). La pluviométrie est caractérisée par une grande variabilité spatio-temporelle. Le **régime thermique** est peu contrasté. Il y a **une grande diversité de formations forestières** avec les savanes qui couvrent 70% des superficies de la région, les forêts 12% et la steppe (environ 8%)[3]. Les types de **sols** (figure 6) sont décrits dans la partie précédente. Tambacounda se trouve dans la zone éco géographique agro-sylvo-pastorale centre Est et Sud Est. La région est très vaste mais enclavée.

[3] Conseil interministériel du 24 avril 2013 région de Tambacounda, CSE

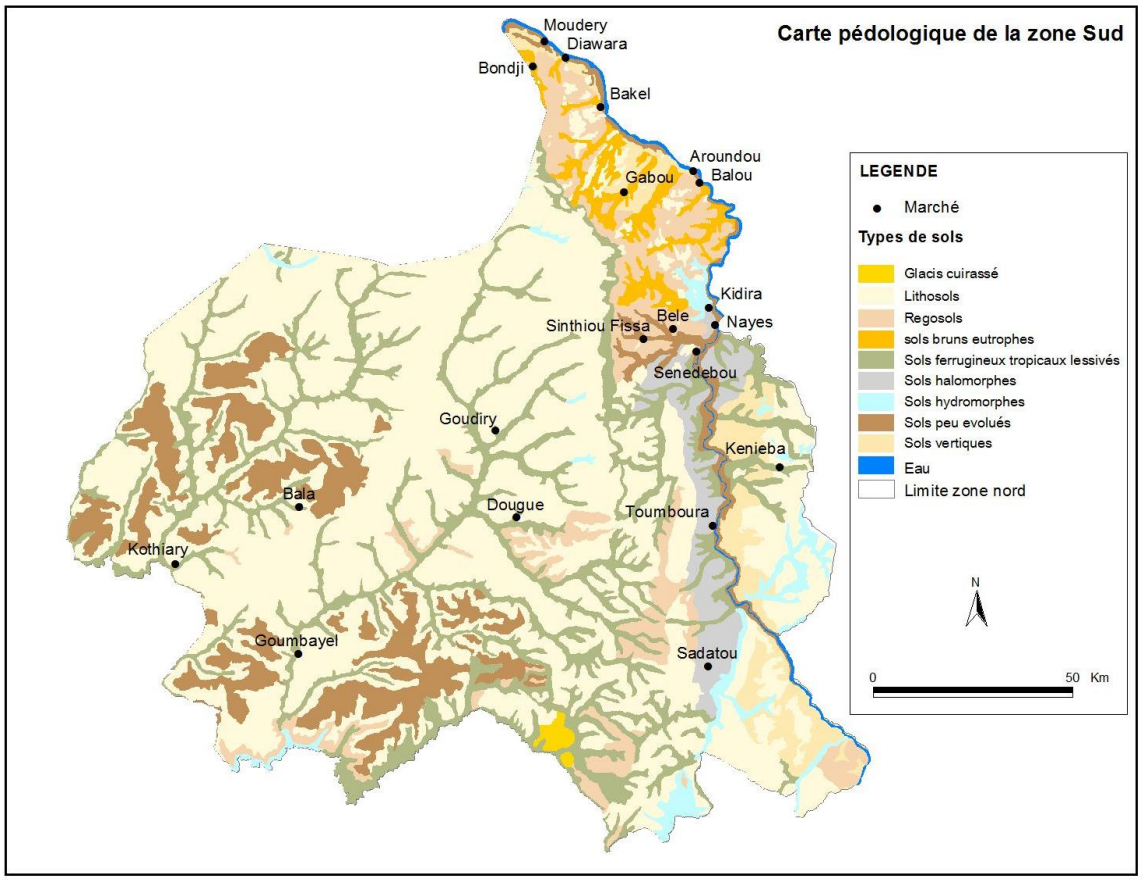

Figure 6: Carte pédologique de la zone sud

2.2.2 Caractéristiques démographiques et socio-économiques

La population de la région est estimée à 630 247 habitants en 2009, soit une densité de 15 habitants au km². Tambacounda compte quatre départements. Ceux de Bakel et de Goudiry, qui constituent la zone sud de l'étude, abritent respectivement 22,3% (140 836 habitants) et 14,6% (91 709 habitants) de la population totale (*Projections démographiques à partir des résultats du RGPH3 ANSD, PAER Tambacounda 2012-2016*). Sur cette base, la densité est de 10 habitants au km2 dans la zone représentant un total de 232 545 habitants sur une superficie de 22 459 km2.

Les principales sources de revenu des ménages sont la vente de bétail, de ressources sauvages (gomme, Jujubes, balanites)[4] et de produits agricoles.

[4]Le troisième pilier fondamental de l'économie de la zone est la vente de produits forestiers d'après le rapport sur le Profil de Moyens d'Existence Agro-Sylvo-Pastorale, Département de Tambacounda, 2011.

2.3 LES POTENTIALITÉS DE LA ZONE D'ÉTUDE

2.3.1 Importance des productions végétales

2.3.1.1 Les productions agricoles

Selon les statistiques de la Direction de l'Analyse et de la prévision des statistiques agricoles (DAPSA) (tableaux 1et 2) sur la production de l'année 2012, les principales céréales cultivées sont le mil, le sorgho, le maïs et le riz avec de faibles superficies de riz (4 ha) dans le département de Goudiry et de maïs dans celui de Matam (90 ha).

Tableau 1: Superficies cultivées (ha) en céréales dans les départements de la zone d'étude

Département	Mil	Sorgho	Maïs	Riz	Production totale céréales (Tonnes)
Bakel	1084	5585	1862	429	7005
Goudiry	7693	3059	5172	4	7124
Kanel	5735	6357	615	829	13838
Matam	9977	5263	90	3891	24521

Source : DAPS 2012

Tableau 2: Superficies cultivées (autres cultures en ha) dans les départements de la zone d'étude

Département	Arachide huilerie	Coton	Niébé	Sésame	Pastèque	Béréf	Bissap
Bakel	451	73					83
Goudiry	5656	916			21		
Kanel	390		312				
Matam	940		1389			214	

Source : DAPS 2012

Avec dix spéculations, la diversification offre une opportunité pour l'adaptation au changement climatique notamment pour le développement de plusieurs cultures (cycle court et variétés disponibles) dont la faible sensibilité à la variabilité climatique peut être un atout. Toutefois, face à l'augmentation des précipitations, combinée à un raccourcissement de la durée des saisons, la recherche sur des variétés capables d'utiliser beaucoup d'eau en un temps court pour produire de bons rendements s'impose.

2.3.1.2 Les productions forestières

Pour appréhender l'évolution de l'occupation du sol, la zone d'étude a été extraite de la cartographie multidate réalisée par la FAO dans le cadre du projet « Africover Project and Global Land Cover Network ». Cette cartographie a été développée en utilisant des images satellites Landsat TM datant des années 1990 et 2005 avec une vérification terrain réalisée en 2008. Deux types de changements sont considérés :

- **la modification** : le mode d'occupation de l'espace a changé d'une classe à l'autre, mais en restant dans la même catégorie (exemple : savane arborée qui devient savane arbustive) ;
- **la conversion** : le mode d'occupation de l'espace d'une classe est passée à une autre classe dans une catégorie différente (exemple : savane arborée qui devient culture pluviale).

Tableau 3: Classification des types de changement

Type de changement	Classes d'origine (Libellé)	Nouvelle classe
Conversion	Savane arborée/Savane arbustive/Steppe arbustive/ Forêt galerie ouverte/Forêt claire - Culture pluviale	Végétation naturelle-culture pluviale
Conversion	Savane arbustive /Habitat	Végétation naturelle-habitat
	Savane arbustive/Forêt relictuelle de gonakier -Sol nu inondable	Végétation naturelle-sol nu
Modification	/ Forêt-galerie ouverte/ Forêt claire/-Savane arbustive	Formation boisée-savane
Modification	Savane arborée-savane arbustive	Savane arborée-savane arbustive
Modification	Savane arbustive/Savane arborée - steppe arbustive	Savane-steppe
Modification	Steppe arbustive à arborée- steppe arbustive	Steppe arbustive à arborée- steppe arbustive
Modification	Forêt relictuelle de gonakier - Végétation aquatique à Typha	Végétation naturelle-prairie

Dans la partie nord de la zone d'étude le changement le plus important dans l'occupation du sol concerne la modification de la savane en steppe perceptible dans les deux départements. Ce changement est intervenu de part et d'autre de l'axe routier national. Dans les zones éloignées il est noté autour de Belel Thiedo, Loumbol Alouki et Dendoudy (Département de Matam) et autour de Namary, de Ranérou oriental et de Lordouga (Département de Kanel). C'est aussi le cas dans la vallée alluviale. La même tendance est notée pour la modification de la steppe arbustive à arborée en steppe arbustive. D'autre part, une évolution régressive est remarquée au niveau de la savane arborée devenue savane arbustive dans les zones à l'écart de l'axe routier, à Matam. A Kanel, elle est localisée le long de l'axe routier, autour de Ndendory. Dans la zone nord, la conversion de la végétation naturelle en terres de cultures est notée de part et d'autre de la route nationale. Cette zone est à vocation surtout agricole avec la pratique exclusive de l'agriculture sous pluie. Elle dispose d'un potentiel important de terres cultivables d'assez bonne qualité. Les céréales (mil, souna, sorgho) sont généralement cultivées dans les grandes parcelles (compris entre 0,5 et 2 ha) exploités par les chefs de ménage.

La production est généralement destinée à l'autoconsommation. Cependant, l'excédent de la production de mil est vendu aux commerçants pour accéder aux produits de consommation courante tels que l'huile, le riz, le savon. De petites parcelles (moins de 0,5 ha) appelés « nambélis » sont exploitées par les femmes qui y produisent en général du niébé, du gombo, du

bissap, de l'arachide, des pastèques et différents légumes[5]. En résumé, dans la zone nord on note une dégradation importante des ressources naturelles surtout perceptible dans la zone du Diéri et particulièrement aux environnants du goudron (de part et d'autre de la RN2). Ceci s'explique en grande partie par une forte pression des populations. La zone de la vallée du fleuve Sénégal (*walo*) est marquée par une dégradation continue des formations forestières constituant une des manifestations de la sécheresse dont les impacts sont aggravés par l'extension des zones de culture (défrichements, feux de brousse...), la pratique de l'élevage extensif (surpâturage, élagage des ligneux) et la surexploitation des ressources forestières.

[5] MEPN/Fonds Italie CILLS Lutte contre la désertification pour la réduction de la pauvreté au sahel. Programme de Gestion Durable des Ressources Naturelles et renforcement de la sécurité alimentaire de la ZARESE de Matam 2009-2010

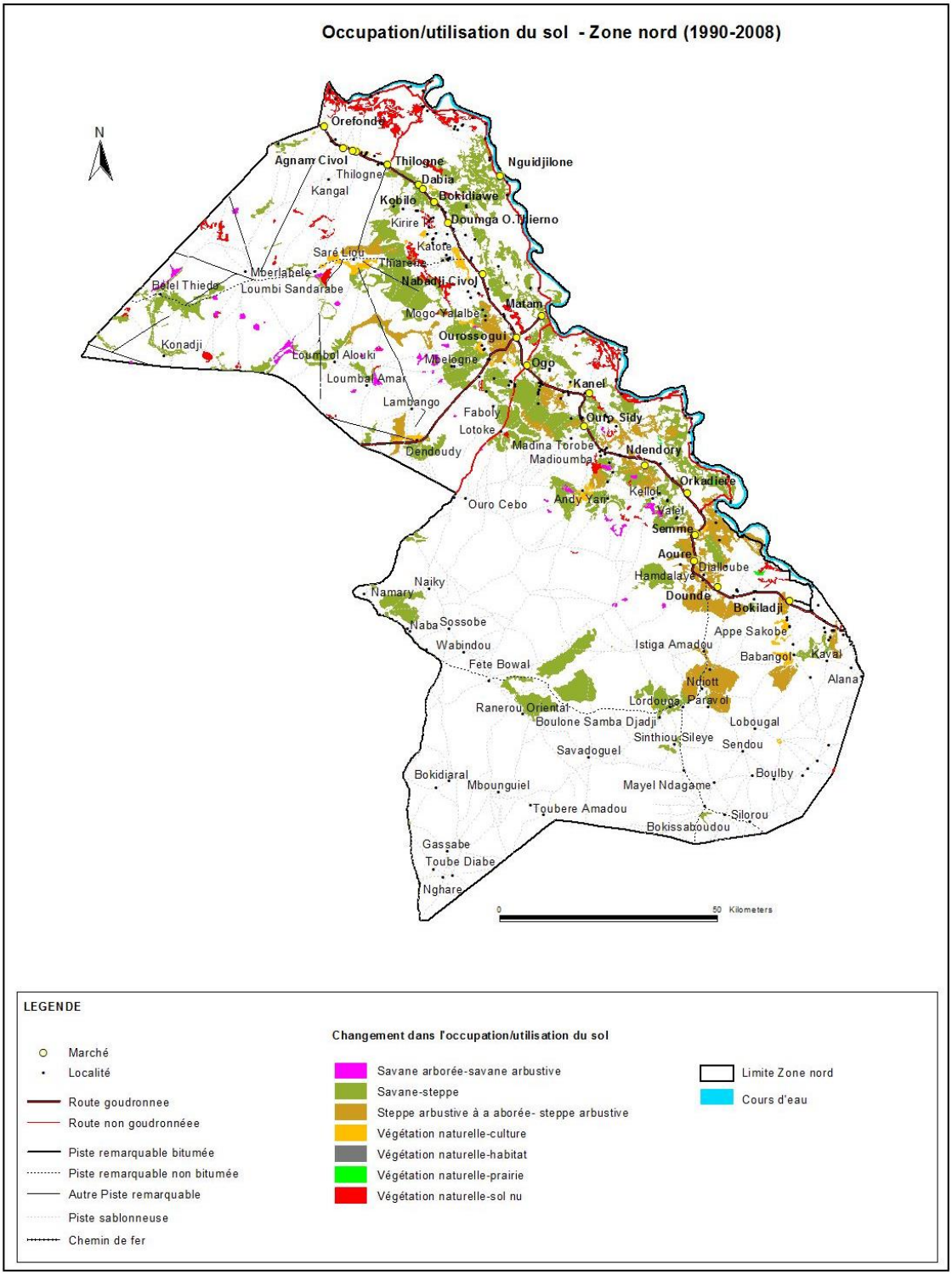

Figure 7: Occupation du sol dans la zone nord

Dans la zone sud, le changement le plus notable dans l'utilisation du sol concerne la conversion de la végétation naturelle en terres de culture perceptible sur toute l'étendue de la zone. Cependant il est plus remarquable dans le nord-est du département de Bakel, autour du village de Goudiry, sur la frange ouest et dans le sud de la zone. La forêt boisée (forêt-galerie, forêt

dense, forêt claire) a disparu au profit de la savane sur une bonne partie de la zone notamment à l'est et au sud de la zone. Elle couvre une bonne superficie le long de la frontière est des deux départements entre Toumboura et Sadatou. La modification de la savane en steppe concerne essentiellement le nord et le centre du département de Bakel. D'autres types de modifications de moindre ampleur (transformation de la savane arborée en savane arbustive (sud de Bala), de la savane arbustive en sol nu ou encore en bâti (autour de Moudery, Diawara, Bakel et dans l'ouest du département de Goudiry) peuvent être constatées.

2.2.1.2 Importance des produits forestiers

Dans un contexte de vulnérabilité par rapport au changement climatique, l'exploitation des produits forestiers surtout par les ménages pauvres représente un des dispositifs de survie pour sortir des méandres de la pauvreté. Il s'agit de leur cueillette et de leur consommation mais aussi du recours à la pharmacopée et à la médecine traditionnelle face à la cherté des soins médicaux. Parmi les stratégies de captation de ressources financières, figure aussi la vente de produits forestiers aussi bien à Matam qu'à Tambacounda.

Ainsi dans la zone nord, hormis la vente de bétail qui représente la plus importante source de revenus monétaires, la vente des produits forestiers non ligneux (gomme arabique, jujubes, pain de singe et le *soump* ou *Balanites aegyptiaca*) chez les ménages les plus pauvres et dans une moindre mesure chez les moyens, est une activité très lucrative. Elle procure aux très pauvres 45% de leur revenu, environ 40% pour les pauvres et 13% dans les revenus des ménages moyens (Analyse de l'Economie des Ménages (HEA) ruraux de la zone sylvo-pastorale du Sénégal, Juin 2013).

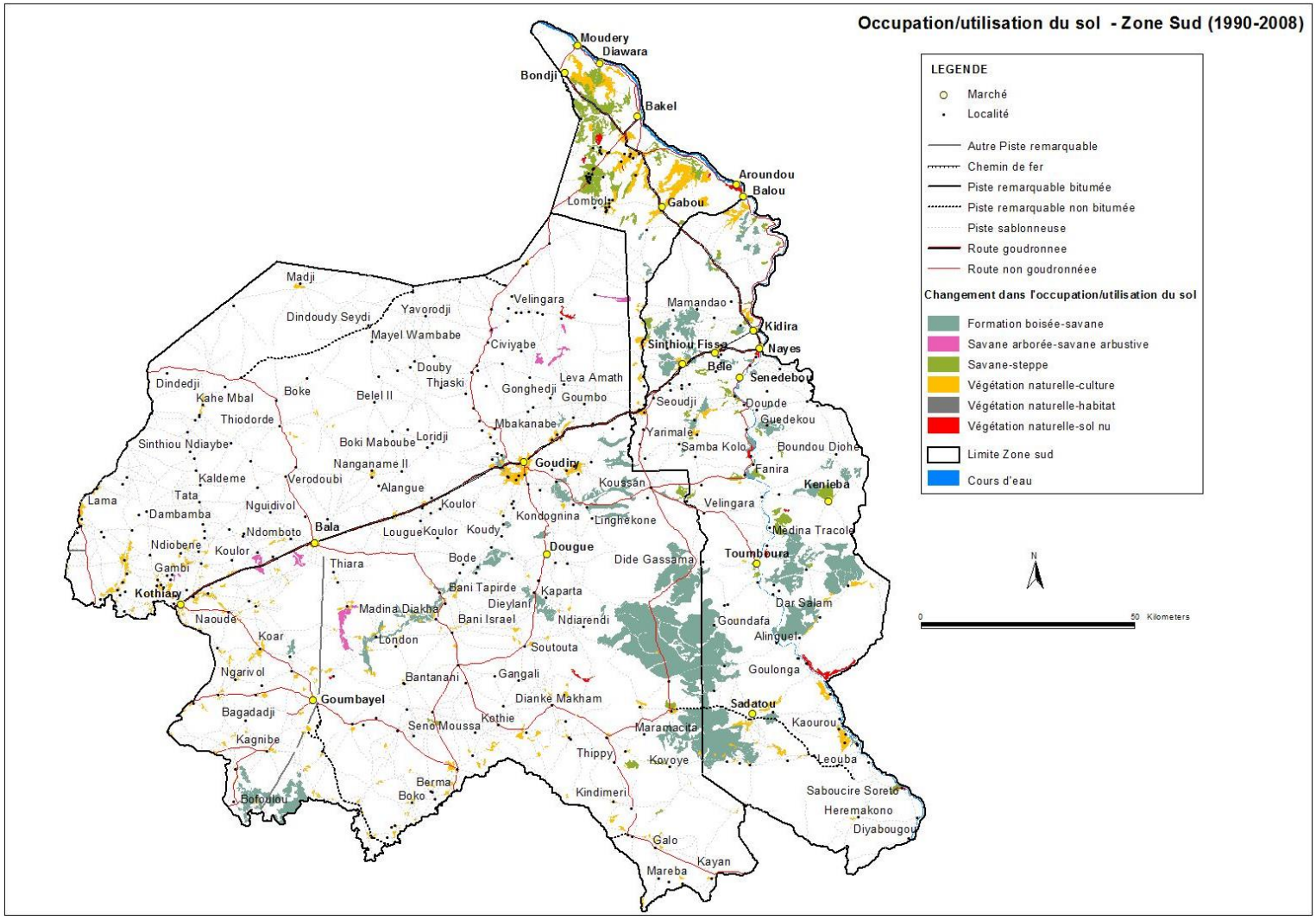

Figure 8: Occupation du sol dans la zone sud

Dans la zone sud, l'exploitation forestière est une activité importante du fait de la disponibilité d'une végétation et d'une faune très riche. Dans la région de Tambacounda existent plusieurs marchés réputés pour les produits sauvages qu'on peut s'y procurer dont Kothiary (pain de singe, gomme mbepp ou Sterculia setigera) et Gouloumbou (fruit de Saba senegalensis). Actuellement la filière gomme est menacée d'extinction du fait d'une surexploitation, des feux de brousse et de mauvaises techniques d'exploitation. La zone représente le dernier bastion de la gomme de Sterculia setigera mais on remarque des difficultés de régénération dues à la fréquence des feux de brousse qui détruisent les jeunes pousses, l'émondage sévère pratiqué par les éleveurs transhumants et le défrichement pour l'agriculture (USAID, 2005). La commercialisation est faîte par les sociétés SOCOGOMME et SETEXPHARM. Les populations organisées en tirent des revenus très importants. Les communautés rurales de Balla, Koar et Koular figurent parmi les zones les plus riches en baobab. Le commerce du pain de singe est facilité par l'existence d'une gare ferroviaire à Kothiary qui permet l'acheminement du produit vers les grands centres de commercialisation (Guinguineo, Diourbel, Touba, Thiès et Dakar).

Les populations exploitent aussi d'autres produits forestiers comme le *dakhar* (*Tamarindus indica*), le karité (*Buturospermum parkii*), le *dimb* (*Cordyla pinnata*), le *siddem* (*Zizyphus mauritiana*), le *leung* (*Vitex doniana*), le *dankh* (*Detarium microcarpum*) ou encore l'*oule* (*Parkia biglobosa*).

Le niveau élevé de dégradation des ressources végétales et fauniques a un impact négatif sur la sécurité alimentaire des populations dans la mesure où il réduit leur l'accès aux moyens de subsistance plus diversifiés et étalés dans l'année.

Dans le cadre d'un scenario de changement climatique favorable à la baisse de la pluviométrie, le stress hydrique entraînera la baisse de la biodiversité floristique et animale. Leurs conséquences seront aggravées par l'explosion démographique qui exacerbera à son tour le déboisement des massifs forestiers comme mécanisme de survie des ménages.

2.3.2 Importance des productions animales

Concernant l'élevage, la zone d'étude est aussi une zone de production animale avec des effectifs importants de petits ruminants et de bovins (tableau 4). Le département de Goudiry étant une nouvelle création depuis 2009, son effectif de bétail est donc dans celui des départements de Tambacounda et de Bakel présentés dans le tableau 4.

Tableau 4: Effectifs de bétail des départements de la zone d'étude

Départements	Bakel	Tambacounda	Matam	Kanel
Bovins	311936	333644	80834	61814
Ovins	264465	739699	298361	77447
Caprins	359994	539657	81643	66628
Porcins	454	486	0	0
Equins	9555	10992	10524	8905
Asins	27272	11651	13639	13639
Camelins	0	0	96	55
Volaille	417807	566008	418580	366257

Source : DIREL 2004 (Goudiry est devenu département en 2009).

Tous les départements de la zone d'étude contribuent de manière significative aux productions animales du Sénégal et se positionnent comme des marchés fournisseurs. Le développement de l'élevage pourrait ainsi permettre de réduire leur vulnérabilité au changement climatique.

De plus, le potentiel de la production laitière dans la zone d'étude s'élève à 7 606 464 litres (tableau 5). Cette production est de 3 808 064 litres dans la zone nord (soit 15 litres par habitant) et 3 798 400 dans la zone sud (soit 7 litres par habitant). Le lait, s'il est valorisé, pourrait ainsi jouer un rôle important dans la sécurité alimentaire de la population.

Tableau 5: Estimation de la production laitière (litres) de 2012

Zone	Effectif total	Vaches lactantes	Production laitière par an	Quantité de lait par habitant
Zone nord	238 004	57 121	3 808 064	15
Zone sud	237 400	56 976	3 798 400	7

Source : Données DIREL, 2012 calculées par le CSE

III - SYNTHESE BIBLIOGRAPHIQUE SUR L'ACCES AUX MARCHE DANS LE SENEGAL ORIENTAL

Cette partie traite de la situation des marchés dans la partie est du Sénégal, des produits commercialisés, des flux commerciaux et de l'insécurité alimentaire qui sévit dans cette zone. En outre, elle fait l'état des lieux en matière de documentation sur l'impact du changement climatique sur l'accès aux marchés.

3.1 Situation des marchés

En dehors des quatre marchés régionaux[6] (Diaobé, Kaolack, Tambacounda et Tiléne) que compte le Sénégal, on distingue généralement trois types de marchés:

- les marchés urbains de consommation ;
- les marchés de regroupement (interface entre les marchés hebdomadaires ruraux et les marchés urbains) ;
- les marchés ruraux hebdomadaires ou *Loumas* selon la terminologie locale.

Un marché rural hebdomadaire est défini comme à la fois un marché de production et de consommation (PAM, 2010). Après les récoltes, le marché rural a pour principale fonction la collecte et l'écoulement des céréales et des produits de rente, ainsi que la vente des produits importés ou manufacturés, aux ménages. Pendant la période de soudure, il change de vocation et devient essentiellement une source d'approvisionnement des ménages en céréales surtout.

Historiquement, les marchés hebdomadaires sont apparus depuis la fin de la période coloniale, et forment des réseaux organisés dans l'espace et dans le temps (Gueye, 2011). Chaque louma se tient, en effet, à un jour déterminé de la semaine, afin de permettre aux vendeurs de se déplacer d'un lieu de

[6] Homologués par le Réseau des Systèmes d'Information des Marchés en Afrique de l'Ouest (RESIMAO).

marché à un autre, d'un jour à l'autre. L'essor de ces marchés a permis l'accès des populations aux numéraires augmentant ainsi leurs revenus.

Les Tableaux ci-dessous donnent une lecture d'ensemble de l'existence des marchés dans les deux régions de la zone d'étude.

3.1.1 Les marchés de la région de Matam

Le commerce constitue la 3ème activité économique des populations dans cette région et intéresse une frange importante de la population. Cependant, il n'est pas très développé dans l'espace villageois, la proportion qui en fait une occupation unique et régulière est faible et tourne autour de 20%[7]. Au total, la région dans son ensemble compte 22 marchés hebdomadaires dont les 11 sont répartis entre les départements de Matam et Kanel (tableau 6).

Tableau 6: Marchés hebdomadaires de la région de Matam

Départements	Localités	Jours de marché Hebdomadaire	Observations
KANEL	Kanel	Jeudi	Louma urbain
	Ourossogui	Mardi	Non fonctionnel
	Orkadiere	Dimanche	
	Ndendory	Vendredi	Partage avec Ounare
	Bondji	Jeudi	
	Doundekoussem	Samedi	
MATAM	Ogo	Lundi	Louma urbain (bétail)
	Nabadji-civol	Mercredi	
	Thilogne	Jeudi	
	Agnamcivol	Mardi	
	Orefonde	Lundi	
RANEROU-FERLO	Ranerou	Jeudi	Non fonctionnel
	Younoufere	Samedi	
	Louguere-thioly	Lundi	
	Thionokh	Vendredi	
	Velingara	Mardi	
	Naoure	Lundi	
	Mbem-mbem	Mercredi	
	Dendoudy dow	Dimanche	
	Barkédji	Mardi	
	Mbam	Lundi	

Source : ANSD/SRSD Matam: Situation Economique et Sociale Régionale, 2010

3.1.2 Les marchés de la région de Tambacounda

Dans la région de Tambacounda, située dans une zone à vocation agricole et pastorale, les marchés jouent un rôle important. D'ailleurs, elle est mieux desservie en établissements commerciaux que la zone nord (tableau 7). En effet, la région de Tambacounda compte 1017 commerçants dont 35 demi-grossistes, 12 marchés permanents et 33 marchés hebdomadaires[8].

Le Service Régional du Commerce de Tambacounda a répertorié plusieurs contraintes liées au bon fonctionnement des marchés et dont les plus significatives sont:

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7 ANSD/SRSD Matam : Situation Economique et Sociale Régionale, 2010.

8 République du Sénégal / Ministère de l'Economie et des Finances : Cellule de Suivi du Programme de Lutte contre la Pauvreté.

- La faiblesse des prix des produits locaux ;
- la pression permanente des produits d'origine frauduleuse (qui font que les produits locaux sont vendus à un prix faible) ;
- les ruptures dans les chaines de conservation des produits.

Tableau 7: Marchés hebdomadaires de la région de Tambacounda

TAMBACOUNDA	Tamba Commune	Permanent (4)	
	Gouloumbou	Heddomadaire	Lundi
	Nétéboulou	Heddomadaire	Mardi
	Dawady	Heddomadaire	Mercredi
	Wassadou	Heddomadaire	Mercredi
	Ndoga Babacar	Heddomadaire	Jeudi
	TivaouneNiani	Heddomadaire	Jeudi
	HamdallayeTessan	Heddomadaire	Jeudi
	Koussanar	Heddomadaire	Vendredi
	Dialocoto	Heddomadaire	Samedi
	SinthiouMalème	Heddomadaire	Samedi
	Missirah	Heddomadaire	Dimanche
	Maka	Heddomadaire	Dimanche
KOUMPENTOUM	Koumpentoum commune	Permanent	
	Méréto	Heddomadaire	Lundi
	AltouFass	Heddomadaire	Mardi
	Payar	Heddomadaire	Jeudi
	Kouthiaba	Heddomadaire	Dimanche
	Bamba Thialéne	Heddomadaire	Dimanche
BAKEL	Bakel commune	Permanent	
	Diawara	Permanent	
	Kidira	Permanent	
	Moudery	Permanent	
	Gabou	Heddomadaire	Lundi
	Kothiary	Heddomadaire	Lundi
	Aroundou	Heddomadaire	Mercredi
	Bondji	Heddomadaire	Jeudi

GOUDIRY	Goudiry commune	Permanent	
	Bala	Hebdomadaire	Samedi
	Kouthiary	Hebdomadaire	Lundi

Source : Service Régional du Commerce de Tambacounda (2012) in Actualisation du document cadre de Référence de la politique Economique et Sociale pour la Période 2013-2017.

3.2 PRODUITS COMMERCIALISÉS ET FLUX COMMERCIAUX

De manière générale, les transactions commerciales et produits échangés dans une localité reflètent en partie la production locale et l'état de l'économie locale. Les deux zones de l'étude ont des moyens d'existence différents: le Nord est une zone d'émigration et d'agriculture sous pluie, le Sud est défini comme étant un milieu Sylvo-pastoral dans lequel l'élevage et l'agriculture constituent les activités dominantes.

Dans la zone Nord, les principaux produits commercialisés concernent les denrées de première nécessité, les produits agricoles (riz, niébé, patate, maïs en particulier), artisanaux, de l'élevage, électroménagers et divers autres produits. Dans la zone Sud (Sylvo-Pastorale), par contre, les produits laitiers, la gomme, le Jujube (fruit de *ziziphus mauritiana*), et le *soump* (fruit de *balanites aegyptiaca*) et la production agricole sont les principaux produits offerts. De plus, les emprunts, transferts d'argent, la vente des produits maraichers, du bois de chauffe, du charbon, du pain de singe, du bétail et de la force de travail constituent de véritables sources de revenus durant la contre-saison.

Les différents documents consultés sur la question des flux commerciaux au Sénégal montrent que les filières des produits agricoles proviennent des différentes zones agro-écologiques du Sénégal et tournent autour des grands marchés de regroupement urbains qui ont une grande capacité de stockage. Les échanges des céréales et de l'arachide par exemple, reposent principalement sur les marchés de Kaolack, Touba, Diaobé et Tambacounda et sur les marchés de consommation que sont ceux de Ziguinchor, Thiès, Louga et Thiaroye-Dakar (CSA/PAM, 2012).

Le riz local est majoritairement produit dans la vallée du fleuve (figure 9). Ses marchés sont structurés autour de circuits commerciaux courts. Le riz importé entre par Dakar provenant de la Thaïlande et du Vietnam. Il se retrouve dans les marchés de regroupement de Saint-Louis et de Dagana où il est vendu en gros ou distribué en détail à travers tout le pays.

Le bassin arachidier est la principale zone de culture du mil (figure 10). Les grands marchés de mil sont Touba et Kaolack qui acheminent le produit vers Tambacounda et Bakel (marchés de gros et de détail). Ces deux derniers sont aussi approvisionnés par le Mali. A partir des marchés de Bakel, Orkadiéré et Matam une partie de la production est écoulée vers la Mauritanie. La production en mil est insuffisante pour couvrir les besoins des ménages qui, pendant la période de soudure, consommeront d'autres céréales.

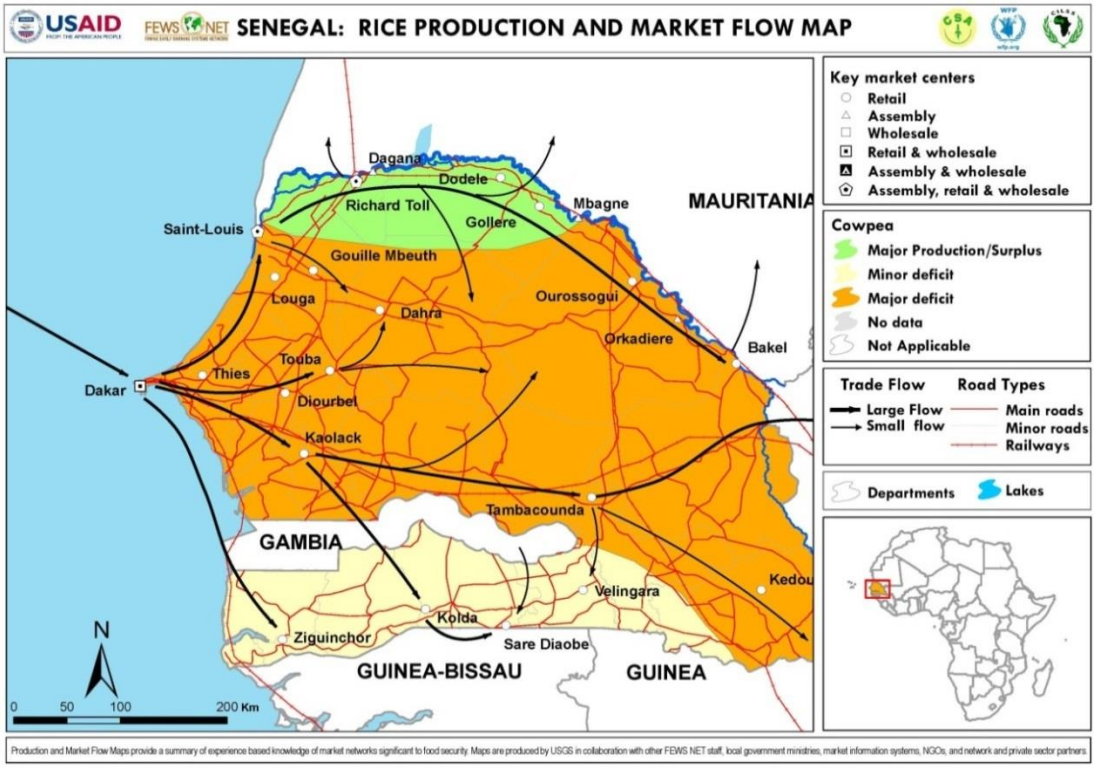

Figure 9: Production et circuits de commercialisation du riz

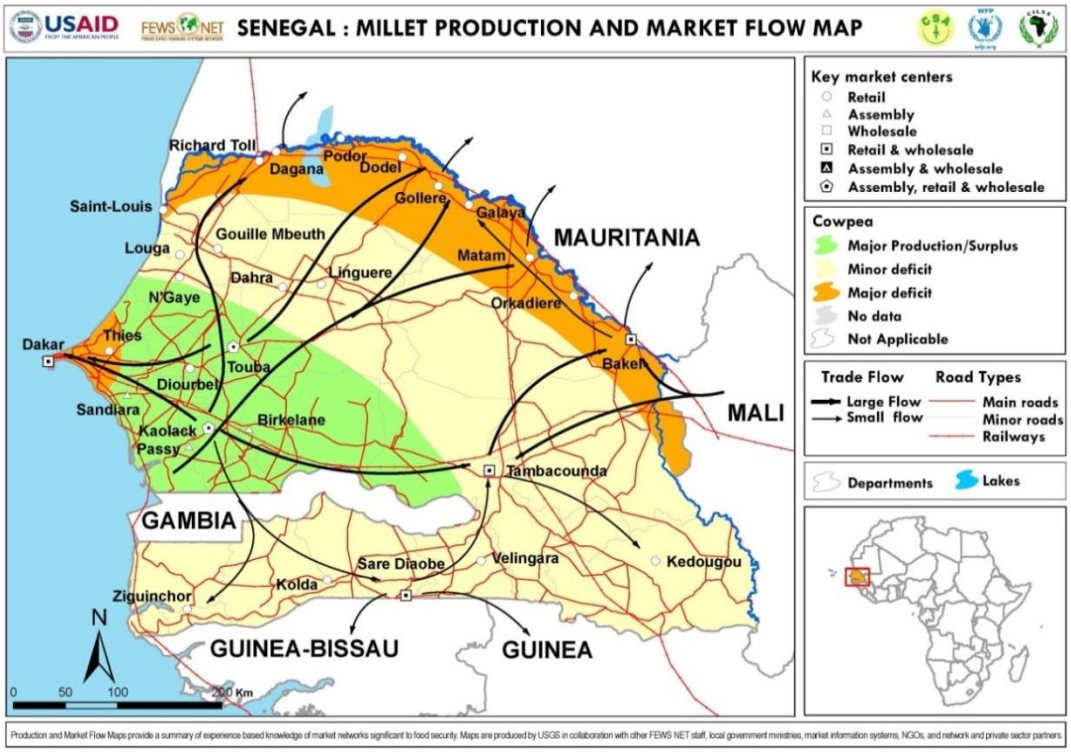

Figure 10: Production et circuits de commercialisation du mil

Quant au maïs, il est essentiellement produit dans la partie sud du pays (régions plus arrosées) mais la consommation est importante dans la zone d'étude (figure 11). Tambacounda, Ziguinchor et Diaobé constituent les marchés de collecte. Il est acheminé vers Matam en provenance de Touba et Kaolack puis vers la Mauritanie. Une partie du maïs consommé vient du Mali via Bakel.

La production de maïs est déficitaire ce qui a pour effet de déclencher une importation de maïs d'outre-mer. En effet, les importations de maïs canadien ou argentin permettent de palier à la faiblesse de l'offre en maïs local, particulièrement en période de soudure, y compris dans des zones productrices de maïs comme la région de Tambacounda. En août 2009, FEWS NET (2009) signalait la présence de ce maïs d'outre-mer sur le marché sénégalais de Bakel, à la frontière malienne (CILSS, FAO, FEWS NET, PAM Commerce Transfrontalier et Sécurité Alimentaire en Afrique de l'Ouest : Cas du Bassin Ouest).

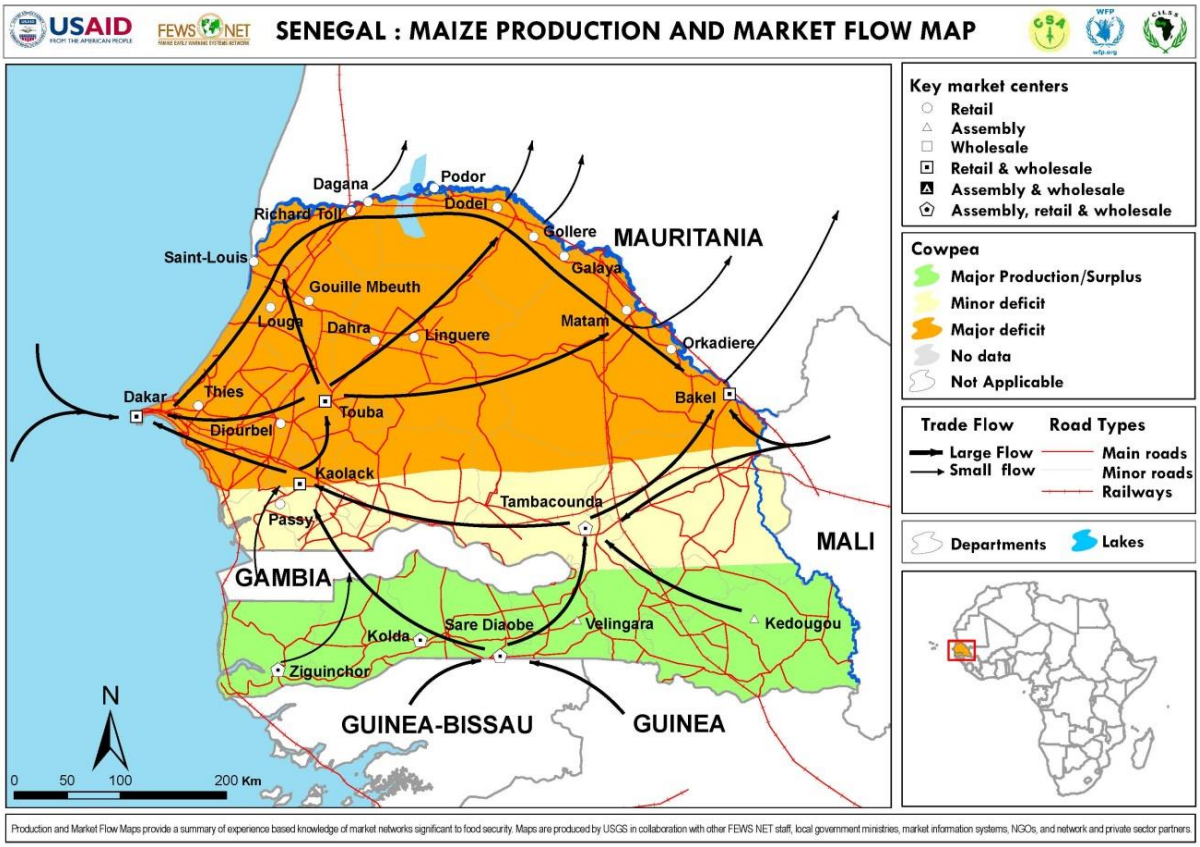

Figure 11: Production et circuits de commercialisation du maïs

Le niébé est semé dans les régions nord de Louga et Saint-Louis et dans le centre nord du pays (figure 12) où la culture concurrence celle de l'arachide. Dans ces parties la pluviométrie est plus faible et la saison des pluies moins longue. Le Mali fournit du niébé aux marchés de Bakel et de Tambacounda tandis que Ourossogui écoule une bonne partie de la production locale vers la Mauritanie.

De manière générale les circuits de commercialisation montrent que les produits céréaliers sont en priorité destinés aux marchés intérieurs. En outre ils présentent la particularité, hors des circuits marchands, d'être en partie fortement autoconsommés. De même, les prix pratiqués à Dakar et dans les grands centres urbains sont plus compétitifs que ceux de la zone d'étude. Ainsi, en cas de déficit céréalier du bilan national, la zone d'étude peut être défavorisée par les circuits d'approvisionnement.

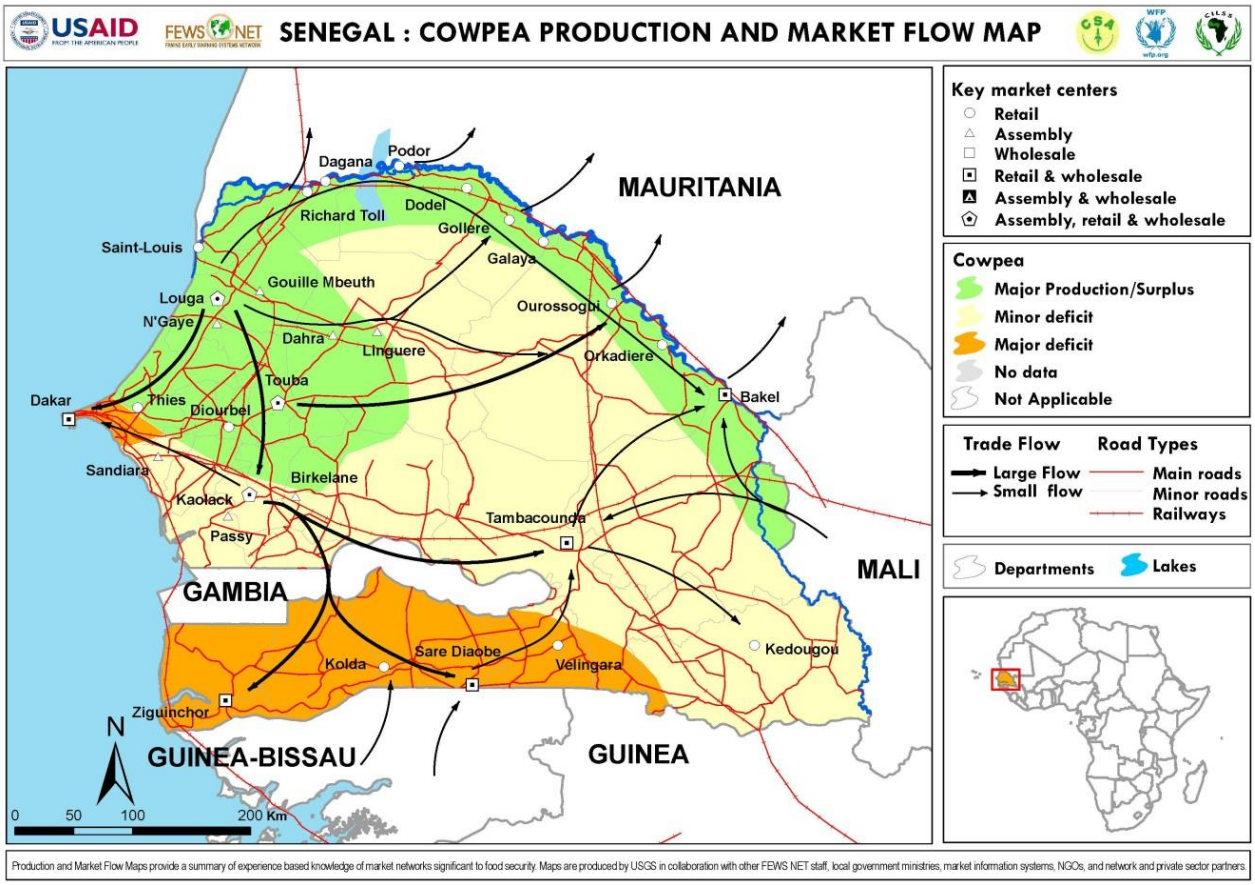

Figure 12: Production et circuits de commercialisation du niébé

Quant aux marchés à bétail ils sont localisés dans la zone sylvo-pastorale (figure 13). Les principaux marchés de regroupement et de gros sont ceux de Thiès, Touba, Dahra, marché de bétail par excellence, Dodèle et Ourossogui, dans la zone d'étude. Ce dernier accueille les troupeaux de la Mauritanie tandis que ceux du Mali transite par Bakel puis Tambacounda pour emprunter un circuit plus méridional autour du grand marché de Sara Diaobé. Le département limitrophe de Ranérou Ferlo (situé à l'ouest de Matam) est l'une des principales zones pourvoyeuses de bétail pour le reste du pays lors des grandes fêtes, notamment la Tabaski.

Au cours de la période d'hivernage et de contre saison, les autres produits du bétail (lait, beurre, fromage, peaux et cuirs) sont disponibles et en quantité suffisante sur les marchés (Profil de Moyens d'Existence Zone SN03 : Vallée, Emigration/Transferts).

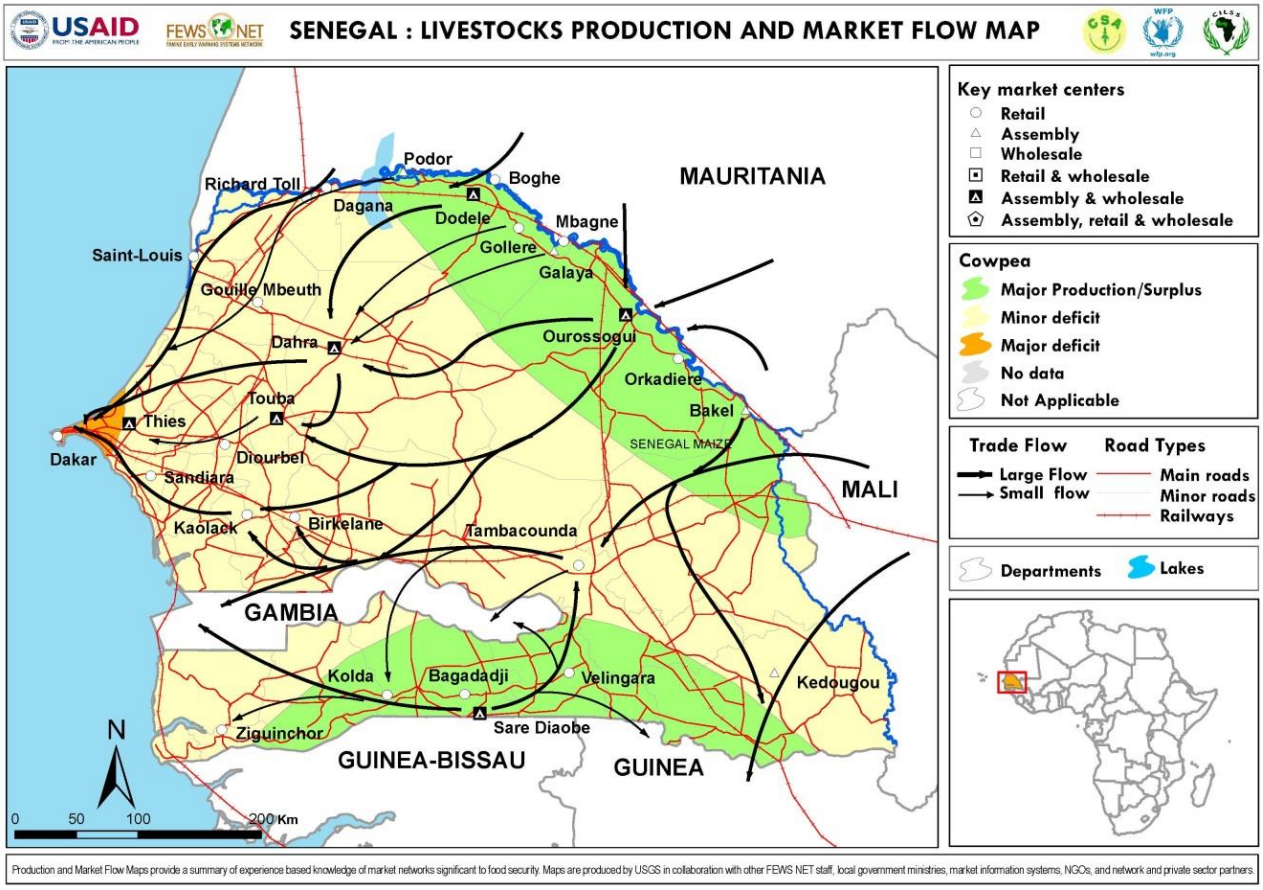

Figure 13: Production et circuits de commercialisation du bétail

La vente de petits ruminants constitue un pilier de la sécurité alimentaire au Sahel. En zone sahélienne, les animaux sont vendus pour faire face à l'imprévu, y compris aux crises alimentaires. Les ventes de bétail et de produits de l'élevage jouent un rôle déterminant dans les revenus des ménages sahéliens en milieu rural. Les ménages sans accès à ces revenus sont également les plus pauvres. Les flux transfrontaliers de bétail permettent le fonctionnement et le développement des systèmes de vie et des mécanismes de survie au Sahel (CILSS, FAO, FEWS NET, PAM Commerce Transfrontalier et Sécurité Alimentaire en Afrique de l'Ouest : Cas du Bassin Ouest).

Les flux commerciaux représentent les mouvements des principaux produits vendus vers les autres horizons pour chaque zone. Il est admis qu'un marché bien approvisionné symbolise d'importants échanges commerciaux mais également une possible satisfaction de la demande en produits pour la consommation des personnes et du bétail.

La zone d'étude constitue aussi bien une zone de production et d'échanges de produits végétaux et animaliers. Elle dépend pour beaucoup, de l'achat de vivres produits hors de la zone. Concernant le sucre et l'huile, les ménages s'approvisionnent généralement en Mauritanie où ces denrées alimentaires sont moins chères qu'au Sénégal.

A noter également que le Gouvernement du Sénégal a fixé les prix du sucre, du riz et de l'huile afin de minimiser la fluctuation des prix sur ces produits importés. Le prix du mil et du mais, par contre, ne font pas l'objet de régulation. Les pauvres qui tirent leur nourriture essentiellement de ces deux produits achetés sont les plus exposés aux effets de la hausse des prix des produits de consommation de base tributaires du bon fonctionnement des marchés.

3.3 CONTRAINTES LIÉES À L'ACCÈS AUX MARCHÉS

Les contraintes relevées dans la littérature sont d'ordre structurel et conjoncturel. Les contraintes structurelles font référence aux infrastructures routières qui conditionnent l'approvisionnement des marchés mais aussi à la distance physique séparant les localités des marchés. En effet l'enclavement constitue un facteur principal de vulnérabilité des ménages qui ne peuvent accéder aux lieux de commerce pour y écouler leurs productions où pour s'approvisionner en produits de base. Quant aux obstacles conjoncturels, ils sont très souvent causés par des facteurs exogènes liés au contexte de crise économique et financière nationale, régionale et internationale et qui impacte la situation locale.

3.3.1 Contraintes structurelles liées à l'accès aux marchés

L'approvisionnement des marchés est compromis par la faiblesse, voire l'absence d'infrastructure routière notamment les pistes de production et l'éloignement de certains villages. Au Sénégal, l'essentiel du transport des personnes et des biens se fait par voie routière.

En effet, selon une récente étude du Ministère de l'Environnement et de la Protection de la Nature, le transport routier représente 90% des déplacements intérieurs des personnes et 90% en volume du transport de marchandises (Diagne, 2002).

Le réseau routier comprend essentiellement:

- les routes nationales reliant les grandes distances entre les régions et pays limitrophes;
- Les routes régionales assurant la liaison entre les départements d'une même région;
- Les routes départementales reliant les communautés rurales à l'intérieur d'un même département;
- Les pistes répertoriées reliant les routes départementales aux centres de production agricole.

Ces pistes sont d'un intérêt particulier pour cette étude, dans la mesure où elles constituent les principales voies de communication pour la population rurale du Sénégal Oriental. Cependant, dans la plupart des cas, elles sont difficiles d'accès, voire impraticables, notamment en saison des pluies. Le tableau suivant donne un aperçu de la répartition des différentes routes existantes sur l'étendue du territoire national. A remarquer que les pistes qui sont les principales voies d'accès des localités rurales totalisent seulement 85 km et seules 2% d'entre elles sont revêtues.

Tableau 8: Répartition par catégorie de routes

	Réseau total	**Routes revêtues**		**Routes non revêtues**	
Catégories de routes	Km	Km	%	Km	%
Routes nationales	3364	2857	85	507	15
Routes régionales	1192	563	47	629	53
Routes départementales	5640	813	14	4827	86
Voieries urbaines	247	241	98	6	2
Pistes répertoriées	4191	85	2	4106	98
Total	14 634	4559	31	10 075	69

Source : Ministère de l'Environnement et de la Protection de la Nature, 2002

Comme l'ont montré les résultats de l'étude sur l'Analyse Globale de la Vulnérabilité, de la Sécurité Alimentaire et de la Nutrition (AGVSAN) réalisée en 2010, au niveau national, la distance moyenne séparant le village au marché le plus fréquenté est de 10 km[9]. Par conséquent l'accès aux marchés demeure un véritable défi pour les ménages ruraux au Sénégal. Dans la région de Tambacounda on note que la distance moyenne séparant un village à un marché est de 17 km et plus de 40% des villages se situent à plus de 10 km d'une route bitumée (CSA/PAM, 2012). Outre le manque d'infrastructures, leur état (praticabilité) constitue un élément important dans l'analyse de l'accès. La dégradation des routes est due à plusieurs facteurs dont l'intensité du trafic, les défaillances dans leur construction dont les types de matériaux utilisés, et les facteurs climatiques qui sont rarement pris en considération lors de la conception et du dimensionnement des infrastructures. Concernant le facteur climatique qui nous intéresse dans le cadre de cette étude, en effet, il constitue une cause aggravante des dégradations routières notamment à fin de l'hivernage. Les nids de poule, les fissures, les orniérages, les épaufrures et les faïençages deviennent plus accentués (Diagne, 2002). Un programme d'entretien routier (PERA) a été mis sur pied en 2007 par l'Etat du Sénégal afin d'entretenir annuellement les routes à travers tout le Sénégal pour la préservation et l'amélioration du réseau routier existant. Cependant, cet ambitieux programme souffre d'un problème de financement adéquat pour sa mise en œuvre (Ministère de la Coopération Internationale, des Transports Aériens, des Infrastructures et de l'Energie, 2012).

Tableau 9: Coût de maintenance des routes revêtues de Matam et Tambacounda

Région	Coût de maintenance des routes revêtues (en FCFA)	Date
Matam	380 001 312	26/05/11
Tambacounda	330 875 512	06/09/11

Source : Ministère de la Coopération Internationale, des Transports Aériens, des Infrastructures et de l'Energie (2012)

3.3.2 Contraintes conjoncturelles

La production céréalière déficitaire (Figure 14) constitue la contrainte majeure de l'approvisionnement des marchés locaux en produits. L'analyse de la figure, permet de voir que les productions couvrent difficilement plus de 55 % des besoins alimentaires.

S'y ajoutent d'autres facteurs tels que le pouvoir d'achat des ménages et le prix élevé des denrées particulièrement celui du riz importé AGVSAN (Figure 15). Or comme le montrent les résultats de l'enquête de l'AGVSAN, la majorité des ménages dépendent des marchés pour leurs besoins alimentaires (riz, huile, sucre, lait). Le prix du riz, par exemple, dont le Sénégal importe plus de la moitié de sa consommation, connaît une hausse exponentielle (Figure 15) depuis quelques années, liée à la perturbation du marché international due aux problèmes de variabilité climatique tels que le réchauffement climatique, les inondations des grands pays exportateurs de ces céréales (CILSS/FAO/PAM/FEWS NET, 2011).

[9] Cet indicateur a permis de conclure que les villages situés au-delà de 10km d'un marché sont en situation de vulnérabilité.

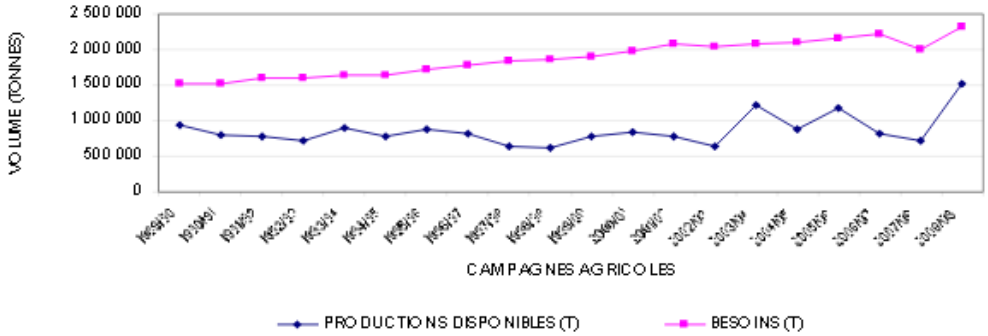

Figure 14: Evolution de la production et des besoins en céréales au Sénégal, durant la période 1989-2009 *(Source: CSA, 2010)*

Ces effets du climat pourraient avoir des conséquences graves sur la production de riz irrigué. En effet, le changement climatique aura un impact direct sur la disponibilité d'eau pour les cultures irriguées (Nelson et al, 2009). Par conséquent, cela va impacter surement la consommation du riz (aliment de base des Sénégalais) au niveau national et compromettre la sécurité alimentaire. Cependant, il apparaît dans les études que le riz local ne semble pas très affecté par ces changements climatiques selon Khouma (2009) contrairement à l'arachide par exemple. D'ailleurs, d'autres études basées sur des scenarios sur la question de l'impact du changement climatique sur le riz montre le caractère bénéfique même de ce changement sur le riz à Madagascar, grâce la fertilisation azotée qui a un fort impact sur les rendements, avec un gain de 1 500 kg/ha de grains pour un apport de 45 kg/ha d'azote (CIRAD, 2012). Par conséquent, une augmentation de la production du riz local notamment dans le Delta pourrait être une solution alternative à la dépendance du riz importé.

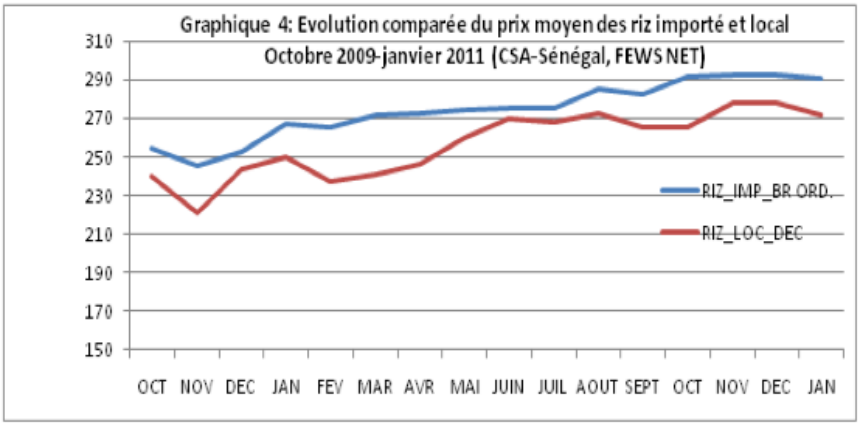

Figure 15: Evolution des prix du riz importé et du riz local sur la période 2009-201[10]

Malgré les engagements du gouvernement Sénégalais de maintenir une stabilité des prix des denrées, ces derniers augmentent affectant le pouvoir d'achat des ménages pauvres de la région d'étude. En outre, l'éloignement des centres de ravitaillement, le manque d'infrastructures de stockage et l'enclavement des zones rurales rendent onéreux le coût du transport et du coup affectent les prix des produits vendus

[10] (CILSS/FAO/PAM/FEWS NET, 2011)

(PAM/FAO/SE.CNSA/CSE/FEWSNET, 2010). D'où la nécessite de l'intégration de ces problèmes structurels dans les politiques de stabilisation des prix et de commercialisation.

Par ailleurs, d'autres risques et aléas identifiés dans la zone d'étude constituent également des contraintes à l'accès aux marchés. Il s'agit des feux de brousse, de la sécheresse, de l'inondation, des pathologies animales, des parasites des cultures, du vol de bétail, du problème de commercialisation des produits lié à l'insuffisance de l'offre de produits agricoles et l'insuffisance de fonds propres (CSA/PAM, 2012) et de la baisse des transferts d'argent.

En définitive, la combinaison de plusieurs facteurs notamment la paupérisation des ménages ruraux, le prix élevé des denrées, une production agricole déficitaire dans certaines zones et le dysfonctionnement de marchés accentuent la vulnérabilité des ménages. Toutes ces contraintes fragilisent la résilience ou la capacité d'absorber les chocs et crises dans le Sénégal Oriental et contribuent à créer une situation d'insécurité alimentaire qui risque de s'aggraver dans un contexte de changement climatique.

Par conséquent, dans les stratégies d'adaptation qui ont été proposées par des experts au niveau national et à l'échelle mondiale, l'accès aux marchés occupe une place centrale notamment dans la prévention du déficit alimentaire.

Il est reconnu que les marchés peuvent aider l'écoulement des ressources vivrières notamment celles à risque. Dans cette optique, il est préconisé, le développement agricole, l'accroissement du commerce et le maintien des prix internationaux pour profiter aux pays pauvres qui importent leur nourriture en période de disette (OMM/PNUE, 2001).

3.4 IMPACTS POTENTIELS DU CHANGEMENT CLIMATIQUE SUR L'ACCÈS AUX MARCHÉS

3.4.1 Projections climatiques dans le Sénégal oriental

Les projections climatiques servent à mesurer les impacts potentiels du changement climatique dans le Sénégal Oriental. Ces projections porteront essentiellement sur les températures et la pluviométrie qui semblent être les facteurs les plus déterminants dans beaucoup d'études sur les modèles de projection. Les Modèles Régionaux de Climat (MCR) ont été développés et utilisés afin de disposer d'informations à l'échelle régionale et locale pour mieux comprendre et évaluer les changements climatiques et leurs impacts (DEEC, 2010). A préciser toutefois l'insuffisance des données réelles à l'échelle locale sur les projections et les impacts mesurables du changement climatique au Sénégal.

A l'échelle mondiale, la communauté scientifique internationale a envisagé plusieurs scénarios afin de prévoir les impacts du changement climatique à travers le monde. Il est admis qu'avec les taux actuels de la concentration des gaz à effet de serre et les émissions de ces gaz dans le futur (au cours des cent prochaines années), il existe de fortes chances que le réchauffement climatique atteigne 4°C ou plus (World Bank, 2013). Au Sénégal, des scénarios de changement climatique ont été élaborés pour les horizons futurs 2031 à 2050 et 2081 à 2100 à partir du modèle régional du climat (DEEC, 2010). La plupart des modèles de projection utilisent les scenarios IPCC SRES pour illustrer les conduits des émissions dans le futur sur la base des différentes hypothèses concernant le changement démographique et le développement social, économique et technologique (Hein *et al*, 2008).

3.4.1.1 Les températures

Plusieurs modèles climatiques ont été élaborés afin de déterminer les effets potentiels de l'augmentation de la concentration des gaz à effet de serre. Certains modèles indiquent que la température moyenne à la surface du globe pourrait augmenter de presque un demi-degré tous les dix ans au cours du siècle à

venir. De 2000 à 2100, les projections des températures moyennes mondiales à la surface sont indiquées pour les six scénarios d'illustration du RSSE et IS92a utilisant un modèle avec une sensibilité du climat moyenne (Diagne 2002). Toujours à l'échelle mondiale, en 2007 le Groupe d'experts intergouvernemental sur le changement climatique (GIECC) avait prédit une augmentation des températures mondiales moyennes de 1,1°C à 6,4°C d'ici la fin du 21e siècle (CTA, 2012).

En Afrique, les projections reflètent plus ou moins la tendance mondiale. Il est reconnu que les projections des températures en Afrique de l'ouest sont assez consistantes, cependant elles ne fournissent pas une image convergente des changements potentiels de la pluviométrie (GIECC, 2007**).**

Au Sénégal, tel qu'il ressort des résultats des différents scenarios sur les changements climatiques, le pays connaîtra une hausse de température sur toute l'étendue du territoire d'ici 2050. Cette hausse sera largement supérieure à 1° (Diagne, 2002; DEEC, 2010). Le graphique ci-dessous fournit une illustration des anomalies positives, traduisant une augmentation de la température par rapport à la moyenne du climat actuel.

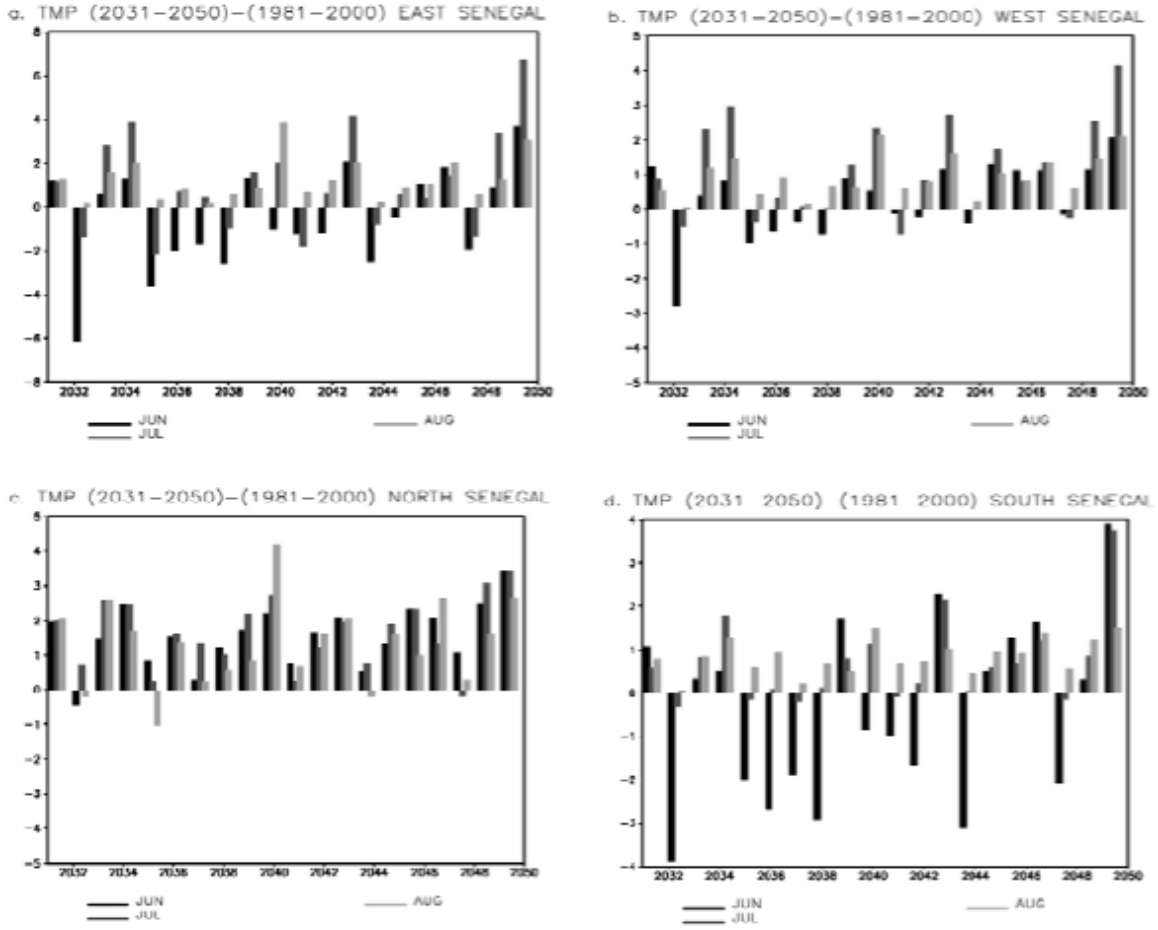

Figure 16: Différences entre la moyenne des températures des mois de juin, juillet et aout du climat futur (2031-2050) et la moyenne du climat actuel (1981-2000) pour le mois correspondant pour l'Est, l'Ouest, le Nord et le Sud du Sénégal[11]

3.4.1.2 La pluviométrie

A l'instar des autres pays au sud du Sahara, le Sénégal souffre également d'une extrême variabilité pluviométrique. Selon les études menées sur le Sénégal (Diagne, 2002; DEEC, 2010; Khouma et al, 2013) les modèles climatiques montrent des anomalies à travers le pays, en particulier durant les mois de juillet et d'aout, accompagnées d'importantes augmentations de température. A l'inverse des projections pour les températures, les précipitations devront diminuer surtout dans la partie Sud du pays à hauteur de -17%. Dans la partie Nord la pluviométrie pourrait connaître une hausse (Diagne, 2002). La figure ci-dessous sur les projections pluviométriques montre que les diminutions les plus importantes vont se produire au Nord et les plus faibles au Sud. Ces diminutions seront beaucoup plus élevées durant la période 2081-2100 au Nord du Sénégal: -50% des journées pluvieuses et plus de -100% pour les fortes précipitations (DEEC 2010).

[11] Source: Deuxième Communication Nationale sur le Changement Climatique, DEEC, 2010.

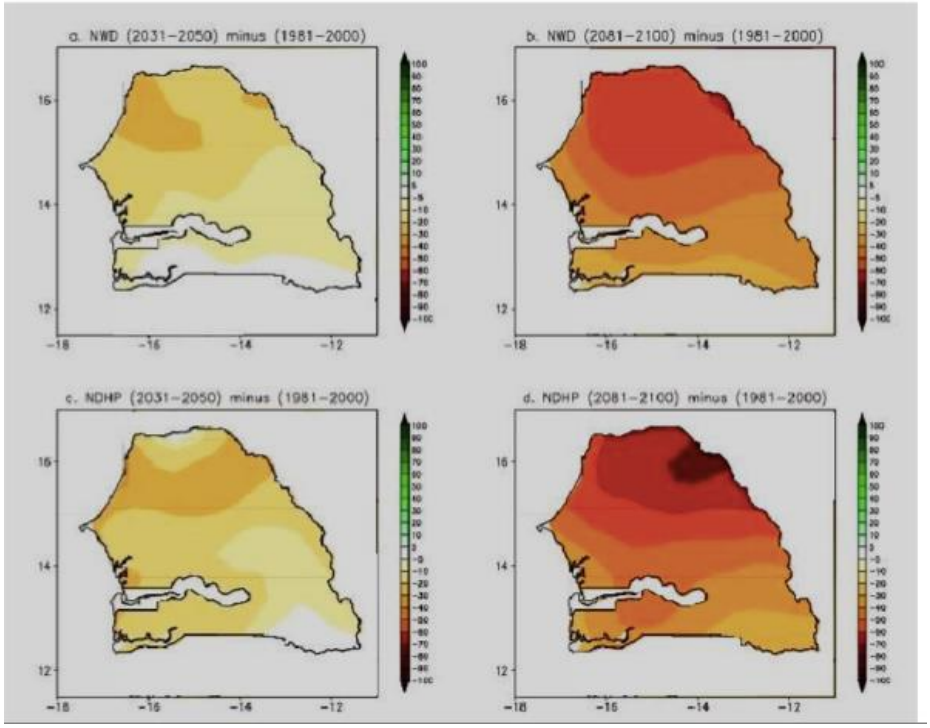

Figure 17: Changement (en %) du nombre de jour pluvieux (a, b) et du nombre de jours de pluies de forte intensité (c, d) entre le climat actuel et le climat futur (gauche 2031-2050 et à droite 2081-2100)[12]

3.4.2 Impacts sur les systèmes de production

En dehors des fluctuations climatiques générales, en ce qui concerne l'Afrique au sud du Sahara, il existe une préoccupation croissante que le changement climatique va intensifier les problèmes de développement (ENDA, 2003, World Bank, 2013). En effet beaucoup d'études faites établissant différents scenarios du changement climatique ont montré que ces impacts vont particulièrement toucher les communautés rurales qui dépendent de ressources naturelles, de l'agriculture sous pluie et de l'élevage comme moyens de subsistance et sources de revenus (OMM/PNUE, 2007; DEEC, 2010; IFPRI, 2013). Sous la menace du réchauffement entre 2 et 4°C, les risques de l'insécurité alimentaire et les menaces sur les écosystèmes en Afrique de l'ouest vont s'accentuer si des mesures d'adaptation et d'atténuation adéquates ne sont pas entreprises.

De plus, avec les fortes chaleurs et la sécheresse comme effets induits de ce changement climatique, les communautés rurales pastorales risquent de perdre une grande partie de leur bétail (World Bank, 2013; Hein et al, 2008). De manière générale, les projections faites sur les impacts du changement climatique sur les systèmes de production et l'approvisionnement des marchés peuvent être regroupés en deux (2) catégories[13]:

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[12] Source: Deuxième Communication Nationale sur le Changement Climatique, DEEC, 2010.

13Selon l'étude "*Southern African agriculture and climate change: a comprehensive analysis*" faite par l' International Food Policy Research Institute (IFPRI), 2013.

- Impacts directs: sur les spéculations agricoles et l'élevage ;
- Impacts indirects : sur l'accès et sur les prix des denrées alimentaires sur les marchés domestiques et internationaux et sur les revenus agricoles.

Au Sénégal, les aléas climatiques et notamment la baisse prévue des pluies risquent de conduire à une sécheresse accrue, d'influer fortement les écoulements de surfaces et de compromettre la production agricole déjà déficitaire dans certaines zones (PAM, 2010). De manière spécifique, les conséquences de ces changements climatiques sur l'agriculture sont:

- Une plus forte demande évaporatoire au niveau des plantes ;
- Un ralentissement de la croissance se répercutant sur les rendements ;
- Des effets négatifs de la submersion des zones de riziculture traditionnelle par les eaux saumâtres.

3.4.3 Impacts sur les infrastructures routières

Nous avons vu précédemment que l'accès aux marchés est conditionné par l'existence de routes et de pistes de production notamment en zone rurale. Beaucoup d'études ont été effectuées sur la question des changements climatiques au Sénégal, toutefois, peu d'entre elles portent sur les impacts de ces changements sur les infrastructures routières et commerciales. Parmi celles-ci, on peut citer le «Rapport de diagnostic sur la vulnérabilité aux changements climatiques du secteur des infrastructures au Sénégal[14] ». Cette étude fait l'état des lieux de la dégradation des infrastructures de transport (portuaires, aéroportuaires, ferroviaires et routières) du au changement climatique. Elle montre également qu'au regard des résultats des différents scenarios développés sur le changement climatique d'ici 2050, la dégradation de ces infrastructures risque d'avoir des sérieuses conséquences socio-économiques et environnementales.

Diagne (2002) montre dans cette étude qu'en dehors de certains facteurs de dégradation tels que le trafic lourd et les surcharges, les pluies aggravent les dégradations des routes. Les nids de poule, les fissures, les orniérages, les épaufrures et les faïençages deviennent plus accentués à la fin de l'hivernage. Ces dégradations peuvent s'accentuer jusqu'à toucher la couche de base et même la fondation et couper les routes en cas d'intensité des précipitations. En addition, une température élevée peut également dégrader les routes, dans la mesure où l'ensoleillement peut détériorer le revêtement bitumineux des chaussées.

IV - ANALYSE SPATIALE DE L'ACCES AUX MARCHES

Pour les besoins de cette étude, l'information sur les marchés, issue de la revue littéraire, a été mise à jour dans les quatre départements concernés avec l'aide des acteurs locaux (agents des services techniques, décideurs). L'accès au marché est conditionné par la disponibilité du produit et l'accessibilité physique du marché et des infrastructures annexes.

[14]Ministère de l'Environnement et de la Protection de la Nature, Programme d'assistance des Pays Bas sur le climat, phase 2

4.1 DISPONIBILITÉ DU PRODUIT

Les marchés jouent un rôle important dans la disponibilité des produits alimentaires auprès des consommateurs. Ils sont donc un facteur déterminant de la sécurité alimentaire notamment dans le contexte du changement climatique qui peut affecter les stocks annuels de vivres.

L'analyse de l'écart maximal (tableau 10) montre que la production de céréale est très dépendante de la pluviométrie dans les deux zones. Le très faible écart des superficies et de la production de riz peut témoigner de cette dépendance car le riz est cultivé dans des conditions où l'eau est maitrisée.

La variabilité de la production annuelle de céréale est très déterminante dans la sécurité alimentaire des populations de la zone d'étude. En effet, dans cette zone dont les moyens d'existence dépendent de la culture sous pluie, de l'élevage et de l'exploitation forestière, un déficit de production de céréale entraine le déstockage du bétail et la pression sur les autres sources de revenu dont l'accès est immédiat (cueillette, main d'œuvre, etc.).

Face à cette situation, les marchés jouent un rôle important dans l'approvisionnement des populations en céréales. L'analyse des marchés va permettre de mieux connaitre les facteurs déterminants pour un bon fonctionnement des marchés contribuant ainsi à la sécurité alimentaire des populations dont les productions céréalières peuvent subir une forte baisse due à la pluviométrie.

Tableau 10: Analyse de l'écart maximal interannuel des productions céréalières dans les deux zones

Zones	Localités		Mil		Sorgho		Maïs		Riz	
			Sup (Ha)	Prod (T)	Sup (Ha)	Prod (T)	Sup (Ha)	Prod (T)	Sup (Ha)	Prod (T)
Zone sud	Bakel	Maximum	19 426	23 175	17 144	17 178	14 256	26 616	500	2 500
		Minimum	1 084	693	3 389	3 091	1 862	862	138	414
		Ecart	**18 342**	**22 483**	**13 755**	**14 087**	**12 394**	**25 754**	**362**	**2 086**
	Goudiri	Maximum	16 519	8 507	5 474	6 240	5 172	2 463	334	835
		Minimum	7 693	3 806	3 059	851	1 973	2 269	4	5
		Ecart	**8 826**	**4 702**	**2 415**	**5 390**	**3 199**	**194**	**330**	**830**
Zone nord	Kanel	Maximum	8 349	10 562	6 357	10 396	615	1 195	829	4 974
		Minimum	5 735	978	4 527	679	507	771	829	-
		Ecart	**2 614**	**9 584**	**1 830**	**9 717**	**108**	**424**	**-**	**4 974**
	Matam	Maximum	19 408	6 890	6 949	2 199	150	308	4 431	26 586
		Minimum	9 977	599	3 653	504	90	-	3 891	23 100
		Ecart	**9 431**	**6 291**	**3 296**	**1 695**	**60**	**308**	**540**	**3 486**

Source : Données DAPSA 2006-2012 (calculées par CSE)

4.2 ACCESSIBILITÉ

L'analyse de l'accessibilité aux marchés est faite à travers le SIG notamment l'utilisation du module « analyse spatiale ». Cette analyse a intégré les données sur la population, les marchés, les voies d'accès et les facteurs physiques de la zone d'étude (relief, pédologie).

4.2.1 Elaboration des produits cartographiques de base

4.2.1.1 Les voies de communication

La zone d'étude est traversée par :

- - les routes nationales RN1 RN2, RN3 et RN7 (figure 18). La dernière se trouve dans un état déplorable. RN2 et RN3 desservent les régions de Saint-Louis, Louga, Diourbel et Tambacounda et représentent un important atout de développement du secteur du commerce. RN3 relie la ville de Linguère à celle de Matam ;
- - la route régionale R42 qui borde le fleuve Sénégal est en réalité une piste latéritique ;
- - dans la région de Tambacounda, le réseau de routes départementales très dense n'est cependant pas bitumé à l'exception du tronçon reliant la RN1 au Sud de Bélé à la localité de Ballou ; les routes correspondent plutôt à des pistes en mauvais état.
- - les pistes répertoriées ne sont pas non plus bitumées.

Outre ces principales voies de communication, le réseau routier est composé de pistes sablonneuses.

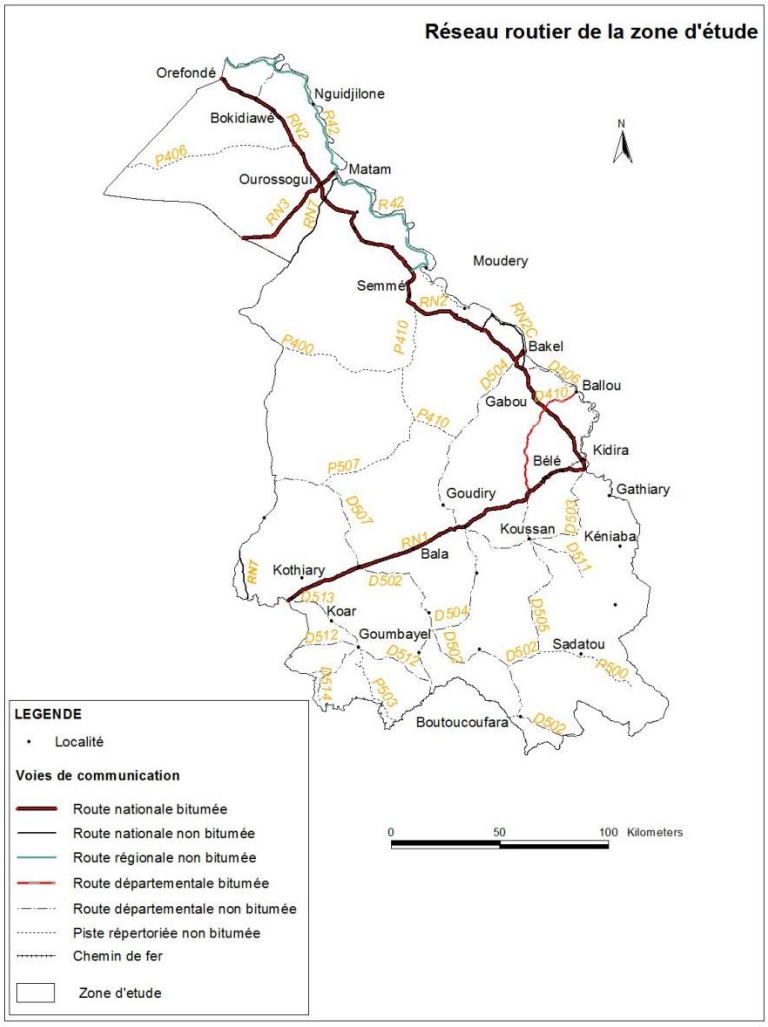

Figure 18: Voies de communication

4.2.1.2 Typologie et maillage des marchés dans la zone d'étude

Trois types de marchés ont été répertoriés dans la zone d'étude (tableau 11 à 14). Il s'agit de marchés : permanent, hebdomadaire, à la fois permanent et hebdomadaire (uniquement dans les départements de Matam et Kanel).

Tableau 11: Marchés hebdomadaires dans le nord de la zone d'étude

REGION	DEPARTEMENT	ARRONDISSEMENT	COMMUNAUTE RURALE	MARCHE	TYPE
Matam	Kanel	Orkadiéré	Bokiladji	Bokiladji	P
Matam	Kanel	Orkadiéré	Aoure	Aoure	P
Matam	Kanel	Orkadiéré	Orkadiere	Orkadiere	P/H
Matam	Kanel	Orkadiéré	Ndendory	Ndendory	P/H
Matam	Kanel	Orkadiéré	Ouro Sidy	Ouro Sidy	P
Matam	Kanel	Orkadiéré	Aoure	Semme	P
Matam	Kanel	Orkadiéré	Aoure	Doundé	P/H
Matam	Matam	Ogo	Nabadji-Civol	Nabadji-Civol	P/H
Matam	Matam	Ogo	Ogo	Ogo	P
Matam	Matam	Ogo	Bokidiawe	Bokidiawe	P/H
Matam	Matam	Ogo	Bokidiawe	Doumga Ouro Thierno	P
Matam	Matam	Agnam Civol	Agnam Civol	Agnam Civol	P/H
Matam	Matam	Agnam Civol	Agnam Civol	Agnam Thiodaye	P/H
Matam	Matam	Agnam Civol	Agnam Civol	Agnam Goly	P/H
Matam	Matam	Agnam Civol	Orefonde	Orefonde	P/H
Matam	Matam	Agnam Civol	Dabia	Dabia	P
Matam	Matam	Agnam Civol	Dabia	Kobilo	P

Tableau 12: Marchés hebdomadaires au niveau des communes dans le nord de la zone d'étude

REGION	COMMUNE	TYPE MARCHE
Matam	Thilogne	P/H
Matam	Ourossogui	P
Matam	Matam	P
Matam	Kanel	P
Matam	Nguidjilone	P

Tableau 13: Marchés hebdomadaires dans le sud de la zone d'étude

REGION	DEPARTEMENT	ARRONDISSEMENT	C. R.	MARCHE	TYPE
Tambacounda	Bakel	Kéniéba	Sadatou	Sadatou	P
Tambacounda	Bakel	Kéniéba	Toumbourou	Toumboura	P
Tambacounda	Bakel	Kéniéba	Madina Foulbe	Kenieba	P
Tambacounda	Bakel	Bélé	Sinthiou Fissa	Sinthiou Fissa	P
Tambacounda	Bakel	Bélé	Bele	Bele	P
Tambacounda	Bakel	Bélé	Bele	Senedebou	P
Tambacounda	Bakel	Bélé	Bele	Nayes	H
Tambacounda	Bakel	Moudéry	Gabou	Gabou	H
Tambacounda	Bakel	Moudéry	Balou	Ballou	P
Tambacounda	Bakel	Moudéry	Moudery	Moudery	P
Tambacounda	Bakel	Moudéry	Balou	Aroundou	H
Tambacounda	Bakel	Moudéry	Moudery	Bondji	H
Tambacounda	Goudiry	Bala	Goumbayel	Goumbayel	P
Tambacounda	Goudiry	Bala	Bala	Bala	H
Tambacounda	Goudiry	Boyngel Bamba	Dougue	Dougue	P
Tambacounda	Goudiry	Boyngel Bamba	Sinthiou Mamadou Bou	Goudiry	P

Tableau 14: Marchés hebdomadaires au niveau des communes dans le sud de la zone d'étude

REGION	COMMUNE	TYPE MARCHE
Tambacounda	Diawara	P
Tambacounda	Bakel	P
Tambacounda	Kothiary	H
Tambacounda	Kidira	P

La cartographie de la répartition des marchés montre qu'ils sont situés le long des principales voies de communication (Figure 19). C'est le cas dans la zone nord, où ils longent la Route Nationale goudronnée à l'exception du marché de Nguidjilone situé au bord du fleuve Sénégal et desservi par le tronçon latéritique de la Régionale 42 qui n'est pas en bon état mais quand même praticable. En effet, l'axe Route Nationale RN2 constitue le centre des échanges de la région de Matam. En outre, la majeure partie des services y sont concentrés (transport, stations de carburant, communication, services financiers…). RN3 relie la ville de Linguère à Matam. La RN7, non goudronnée, est utilisée par les camions pour rallier Tambacounda et la partie sud du pays.

Le système de marché de la région est composé de marché de gros (particulièrement le marché de Ourossogui) et de détails (marché hebdomadaires ou « *Louma* »). Le marché quotidien de Ourossogui par sa position géostratégique de carrefour entre les routes nationales RN2 et RN3, est le principal de

la région. On y trouve en toutes périodes l'essentiel des produits agricoles, d'élevage et de pêche. De plus, les intrants et autres matériels de production y sont disponibles. Dans le circuit de marché, Ourossogui approvisionne les principaux marchés de détail de la zone : Orkadiéré, Ndendori, Kanel, Bondji, Bokidiawé, Agnam Thiodaye, Thilogne, Ouro Sidy, et Matam. Les marchés hebdomadaires de la région sont organisés en fonction des jours de la semaine). Quant au *louma* de Orkadiéré c'est le premier marché céréalier de la région par l'importance des volumes et flux commerciaux, mais surtout par son envergure sous régionale. En effet, ce marché est très prisé par les acteurs locaux, les commerçants des régions voisines (Tambacounda, Louga et Saint Louis) et est fréquenté par des commerçants de la Mauritanie et du Mali. De Orkadiere, les autres *louma* sont suffisamment bien approvisionnés en produits des pays voisins. Enfin, le premier marché de bétail est celui de Thilogne (Profil de Moyens d'Existence Zone SN03 : Vallée, Emigration/Transferts).

Dans la zone Sud, la Route Nationale RN2 constitue la seule voie goudronnée et dessert également l'essentiel des marchés. Les tronçons qui conduisent aux marchés de Toumboura, Sénédoubou, Goumbayel et Dougué ne sont pas goudronnés et présentent un mauvais état. Sadatou et Kéniéba sont accessibles respectivement par une piste impraticable et une piste sablonneuse. Les marchés situés le long de la route nationale goudronnée (Kothiary, Bala, Goudiry, Sinthiou Fissa, Bélé, Kidira et Nayes) profitent aussi de la voie ferrée.

La majorité des marchés de la zone sud sont situés dans le département de Bakel qui se trouve au carrefour de trois pays : le Sénégal, la Mauritanie et le Mali. La zone Bakel – Sélibaby (Mauritanie) – Kayes (Mali) constitue ce qu'on appelle le « triangle de l'émigration ».

Dans Goudiry tous les marchés sont localisés au sud de la route nationale. Les marchés hebdomadaires drainent l'essentiel des produits pour des raisons d'enclavement des autres zones et communautés rurales du Bakel. Cependant, le marché hebdomadaire de Bondji devient de plus en plus un pôle économique dans le département de Bakel. Les commerçants viennent du Mali, de la Mauritanie et de l'intérieur du Sénégal pour écouler toutes sortes de produits.

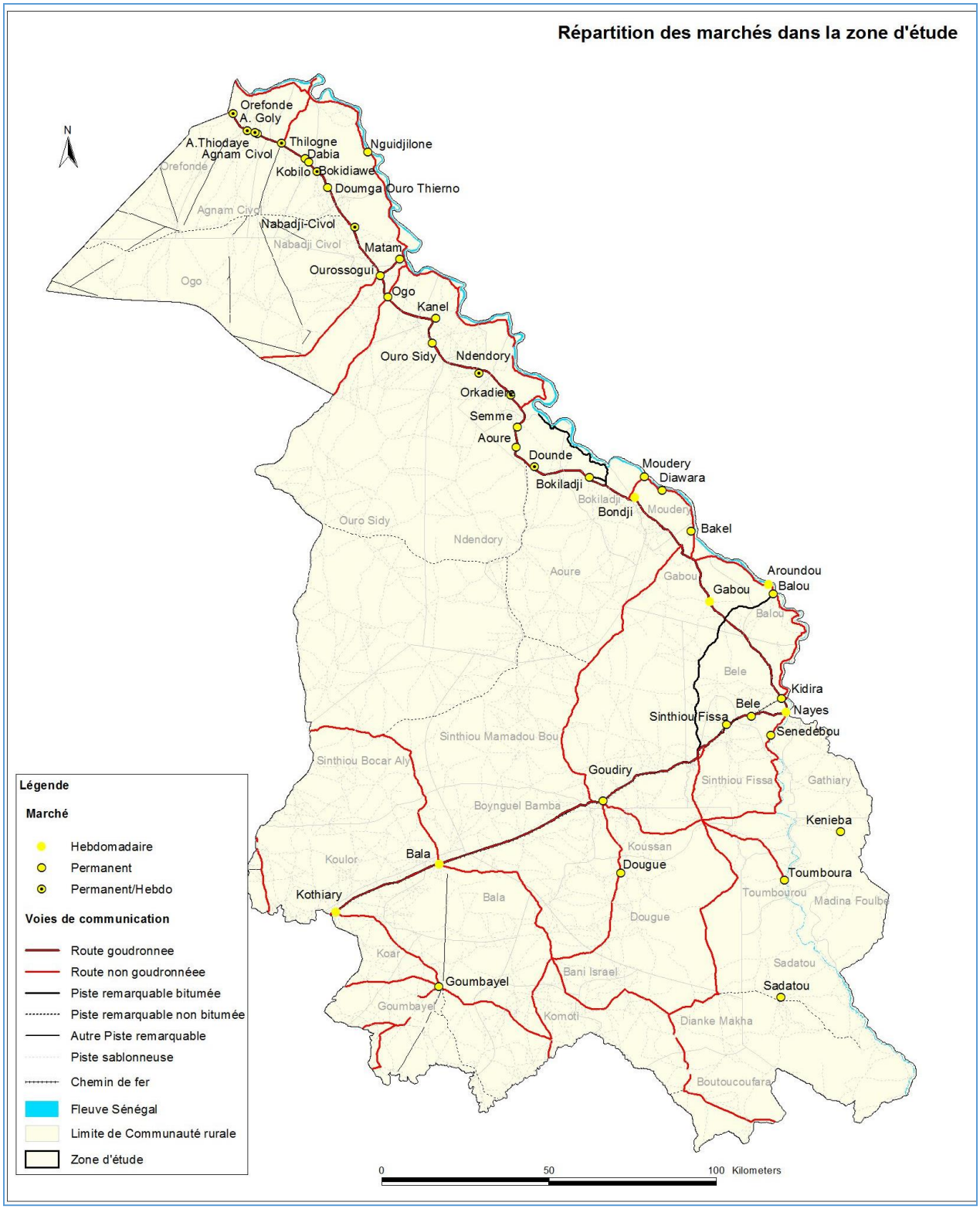

Figure 19: Répartition des marchés dans la zone d'étude

4.2.1.3 Dérivation de la distance par rapport au marché

Les aires de polarisation des marchés (figures 20, 21, 22) ont été estimées selon un pas graduel de 5 km. Au-delà de dix kilomètres les localités sont en situation d'insécurité alimentaire. Le calcul de la distance par rapport au marché a permis d'estimer le nombre de localités de la zone d'étude situées dans un rayon de 10 km d'un marché à 42% et, au-delà de 10 km, à 58%. Cependant ce résultat cache des disparités (tableau 13). En effet l'accessibilité physique au marché est plus contraignante dans la zone sud (75% contre 35% dans la zone nord). Dans la zone nord, c'est surtout dans le département de Kanel (46% contre 25% à Matam) que les populations sont confrontées à ce problème.

Dans la zone sud, le département de Goudiry abrite seulement cinq sur les vingt marchés recensés et les localités situées à plus de 10 km d'un marché représentent 82% contre 62% à Bakel.

Tableau 15: Distance par rapport aux marchés

	Région	Département	Nombre de Villages	Nombre de villages distants de -10km d'un marché	Nombre de villages distants de +10km d'un marché	% de villages distants de -10km d'un marché	% de villages distants de +10km d'un marché
Zone Nord	MATAM	Kanel	149	81	68	54	46
		Matam	154	116	38	75	25
		Zone Nord	**303**	**197**	**106**	**65**	**35**
Zone Sud	TAMBA	Bakel	154	58	96	38	62
		Goudiry	274	51	223	17	82
		Zone Sud	**428**	**109**	**319**	**25**	**75**

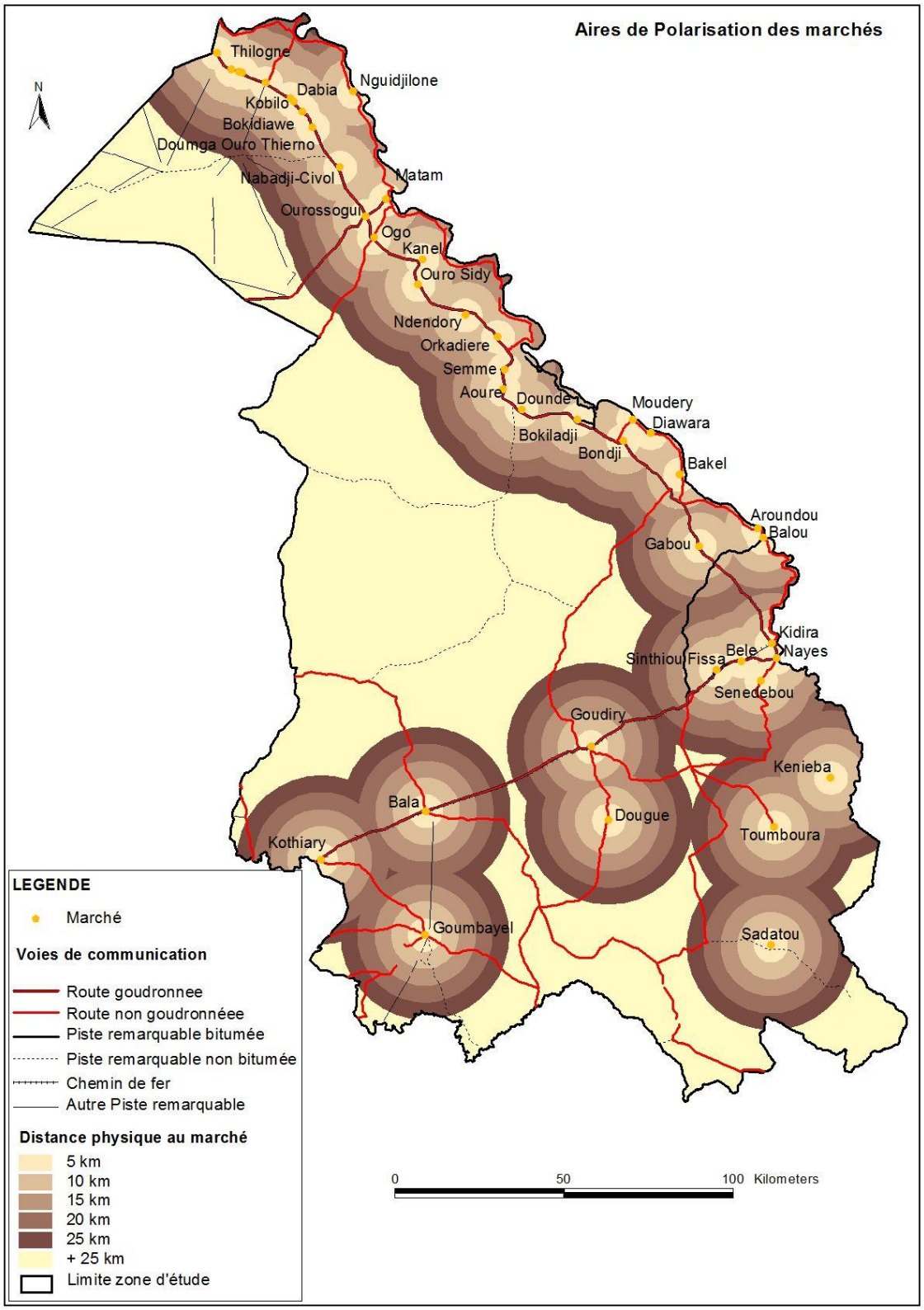

Figure 20: Aire de polarisation des marchés dans la zone d'étude

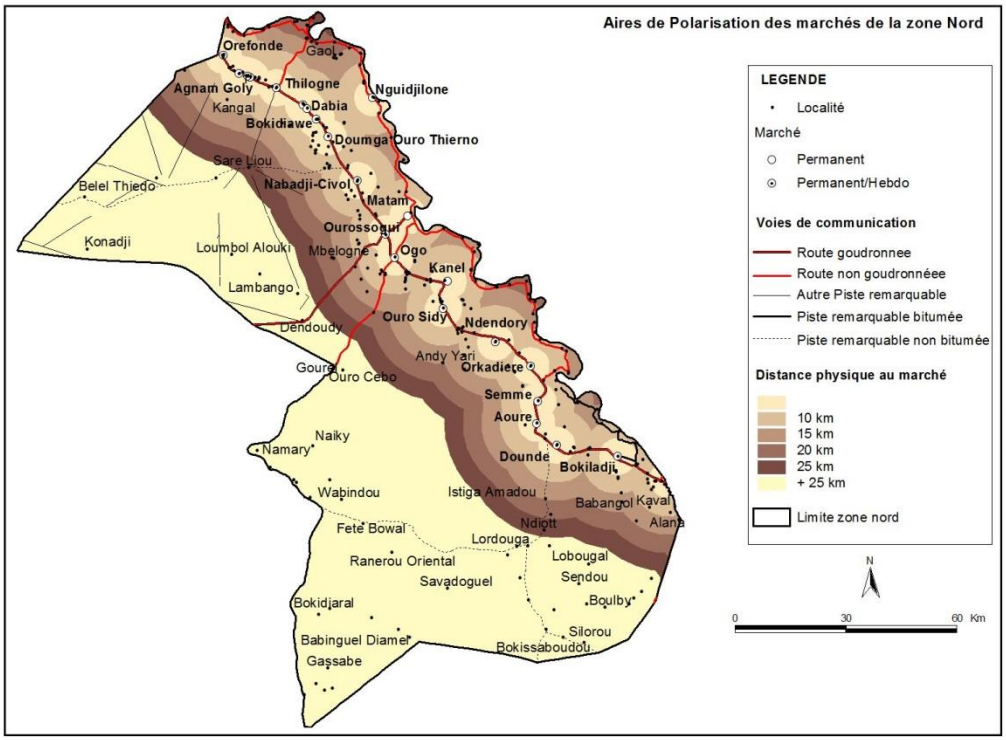

Figure 21: Aire de polarisation des marchés dans la zone nord

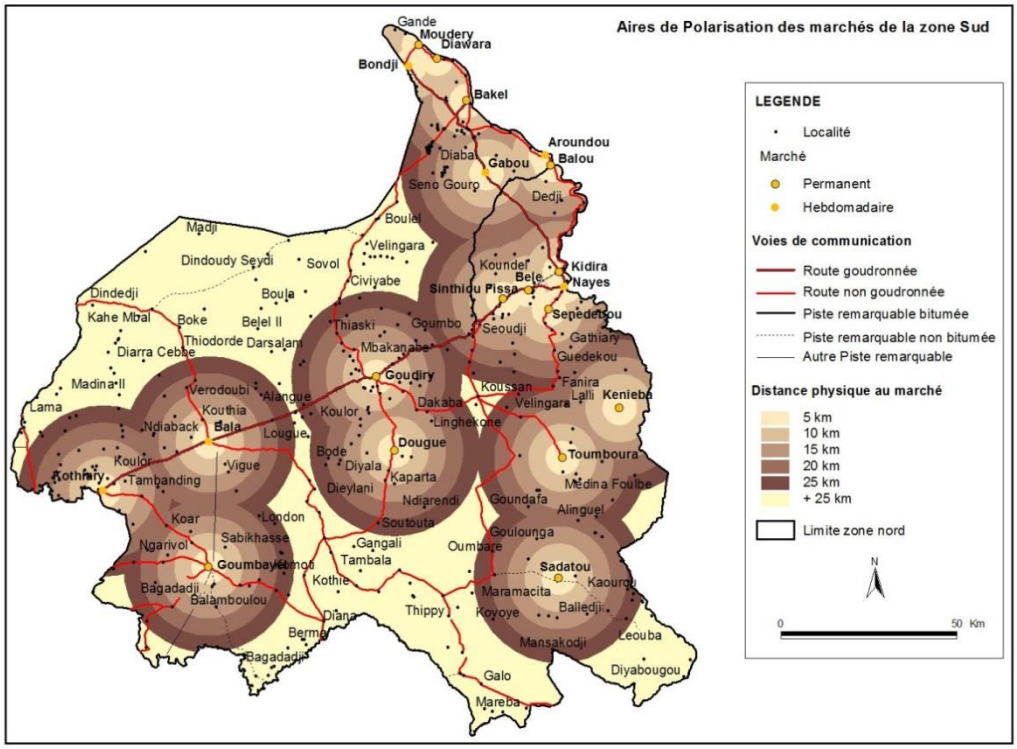

Figure 22: Aire de polarisation des marchés dans la zone sud

En dehors de la distance physique au marché, l'accès a été estimé en tenant compte de la population. Pour cela la couche géographique des localités situées dans un rayon de 10 km autour des marchés a été

sélectionnée et une sommation de leur population a été effectuée dans la table attributaire pour déterminer la population totale polarisée par les marchés. Par la suite cette population a été divisée par le nombre de marchés pour chaque département et pour chaque zone. Le résultat a montré que dans la zone nord, seul 36% de la population ont un accès acceptable aux marchés (soit 176 031 habitants) avec une répartition allant de 31% dans le département de Matam qui compte 16 marchés et 44% dans le département de Kanel qui compte 8 marchés (tableau 16). Le nombre d'habitants par marché s'élève à 8001 variant de 6029 habitants dans le département de Matam à 11 453 habitants dans le département de Kanel.

Tableau 16: Taux de population ayant un accès satisfaisant aux marchés

	Population globale	Population accédant aux marchés	Proportion de population accédant aux marchés	Nombre d'habitants par marché
Département de Kanel	209621	91620	44%	11453
Département de Matam	276502	84411	31%	6029
Zone Nord	**486123**	**176031**	**36%**	**8001**
Département de Bakel	140836	43735	31%	2916
Département de Goudiry	91709	15080	16%	3016
Zone Sud	**232545**	**58815**	**25%**	**2941**

Dans la zone sud, seul 25% de la population accèdent aux marchés. Cette moyenne est répartie entre 16% dans le département de Goudiry qui compte 5 marchés et 31% dans le département de Bakel qui abrite 15 marchés. Le nombre d'habitants par marché varie entre 2916 habitants dans le département de Bakel et 3016 habitants dans celui de Goudiry.

La différence entre les zones s'explique par le fait que la zone nord est plus peuplée que la zone sud (figure 23) ; le nombre moyen d'habitants par localité s'élève à 967 habitants au nord alors que dans la zone sud il s'élève seulement à 478 habitants. La carte de la population montre aussi que les localités de Kanel ont un poids démographique supérieur à ceux de Matam. Elle révèle aussi une nette dichotomie entre Bakel et Goudiry.

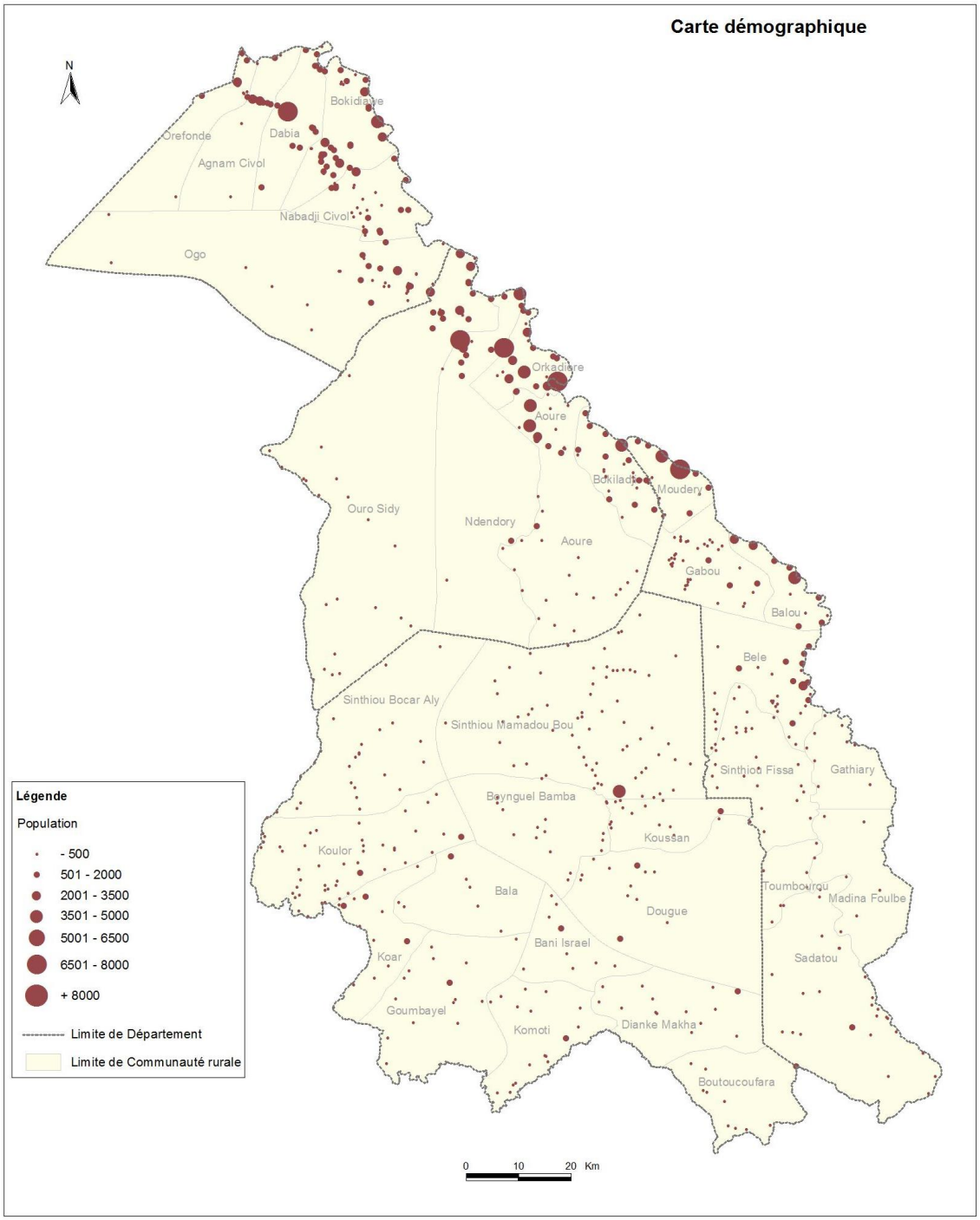

Figure 23: Carte démographique de la zone d'étude

4.2.1.4 Dérivation de la distance par rapport aux principales voies de communication

L'accessibilité a été appréciée en tenant compte aussi des voies de communication les plus importantes notamment route goudronnée/non goudronnée, piste bitumée / non bitumée, piste latéritique, chemin de fer (figures 24 et 25).

Dans la zone nord l'accès semble meilleur dans le département de Matam. Une bonne partie des localités de Kanel sont enclavées. C'est le cas à Ouro sidy et à Ndendory où de petits villages ou hameaux situés dans le haut *Diéri* et le *Ferlo*, sont isolés et complètement coupés du reste de ces Communautés rurales. Ces localités sont sises dans une zone de pâturage traversée uniquement par des pistes sablonneuses. Cette situation est retrouvée dans la communauté rurale de Aouré.

Dans la zone sud, l'accès est faible dans l'est et le sud du département de Bakel. Le marché de Kéniaba, très éloigné, n'est accessible que par des pistes sablonneuses. Le réseau routier est plus développé au sud de la route nationale, dans le département de Goudiry.

Toutefois l'analyse de l'accessibilité physique au marché doit être complétée par l'information sur la praticabilité des voies de communication. L'état général du réseau routier est défectueux, en particulier pour les routes non revêtues et les piste (SES Matam). C'est le cas des pistes reliant le Walo et le Diéry comme celle partant de Thilogne en direction de Saré Liou longue et difficilement praticable en saison hivernale.

La route régionale appelée « route du fleuve », n'est pas en bon état bien que praticable. La zone nord ne dispose que de deux axes routiers bitumés en bon état la RN2 et la RN3. La RN2 traverse toute sa partie nord sur environ 200 km du Nord-ouest au Sud-est.

La praticabilité doit aussi être liée à la topographie, l'hydrographie et la pédologie de la zone. Dans la vallée alluviale du fleuve *Sénégal,* zone argileuse soumise aux crues annuelles de ce cours d'eau, la plupart des pistes (exemple celles reliant Ngano-Soringho-Kanel, Barmathial-Hamady Ounaré, Bapalel-Hamady Ounaré) sont coupées par de petits marigots et la circulation est impossible après les pluies (PLD de la Communauté rurale de Ndendory).

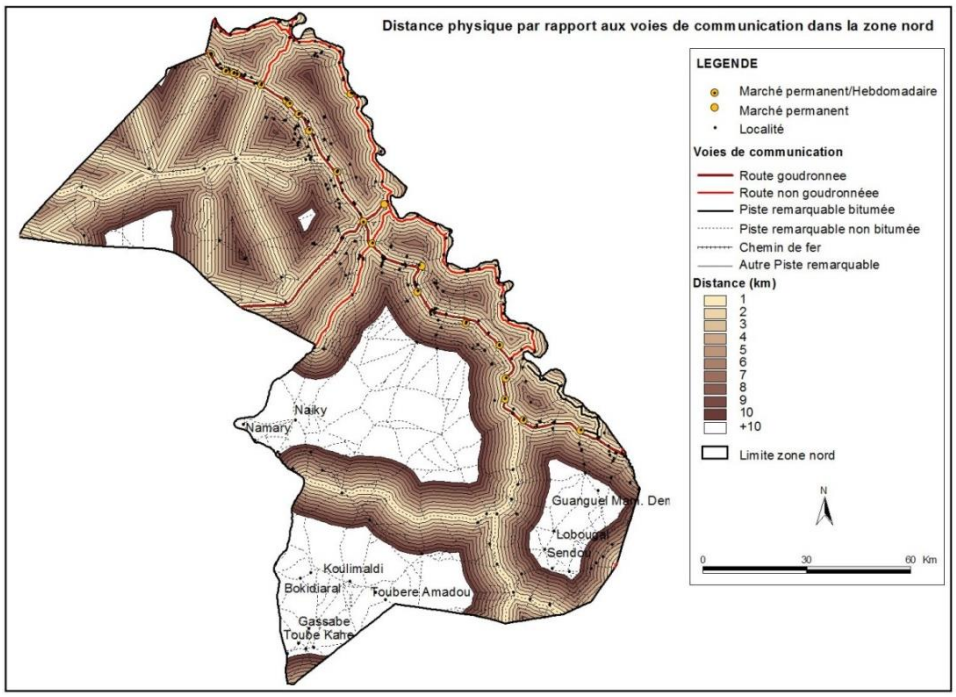

Figure 24: Distance physique au marché dans la zone nord

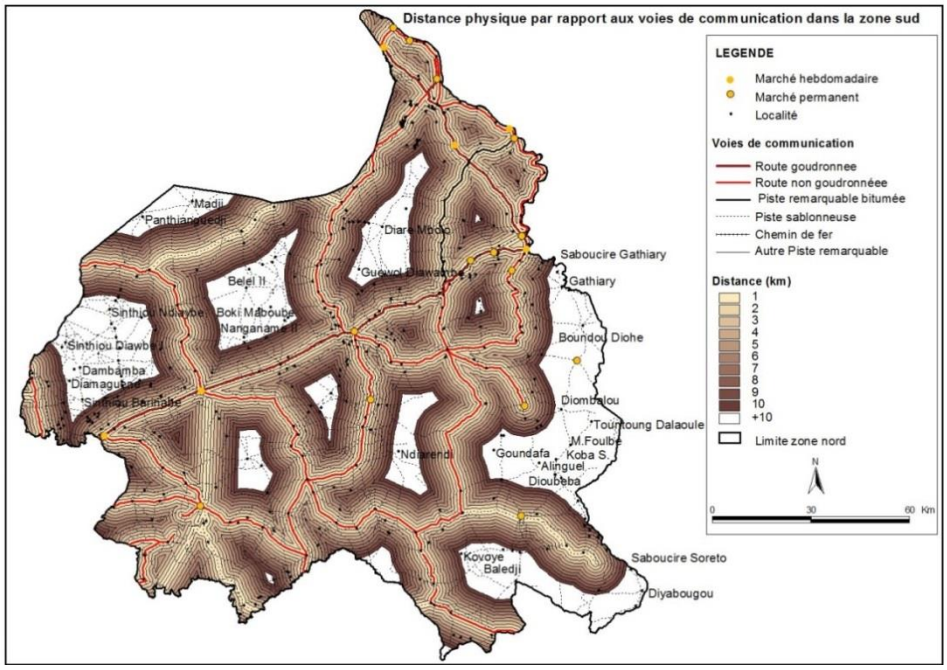

Figure 25: Distance physique au marché dans la zone sud

4.2.1.5 Topographie de la zone d'étude

Le Modèle Numérique de Terrain (MNT) donne une image raster en niveau de gris avec une échelle de valeurs qui augmentent en fonction de l'altitude (Figure 26). Plus la couleur est claire, plus le point est élevé. Cette image a été transformée en shape file pour pouvoir afficher les valeurs des classes d'altitude (Figure 28). Dans le sud-est de la zone d'étude le relief culmine à plus de 300 m d'altitude annonçant les contreforts du Fatou Djalon. Le département de Bakel est bordé par une dorsale représentant un relief situé entre 100 et 132 m. Cependant en raison de la faiblesse des pentes (Figure 27) dans la zone d'étude (inférieures ou égales à 10%) la topographie ne semble pas trop influer sur l'accès aux marchés. Aussi, les localités situées à une altitude de plus de 100 m correspondent à celles qui sont insubmersibles en saison des pluies.

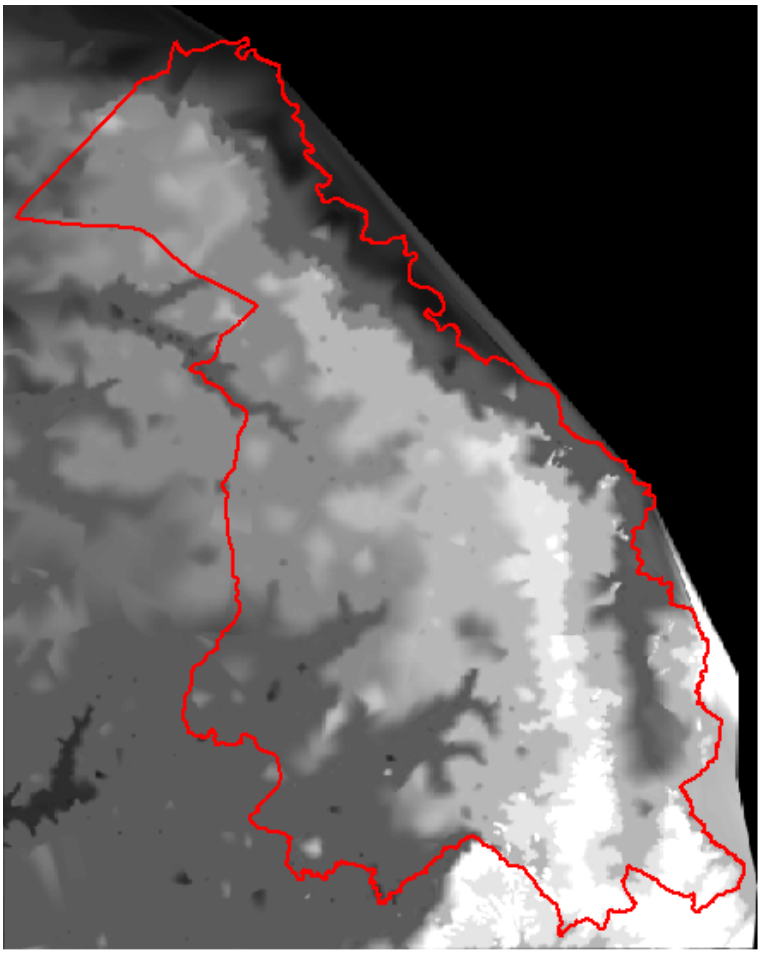

Figure 26: Modèle numérique de terrain de la zone d'étude

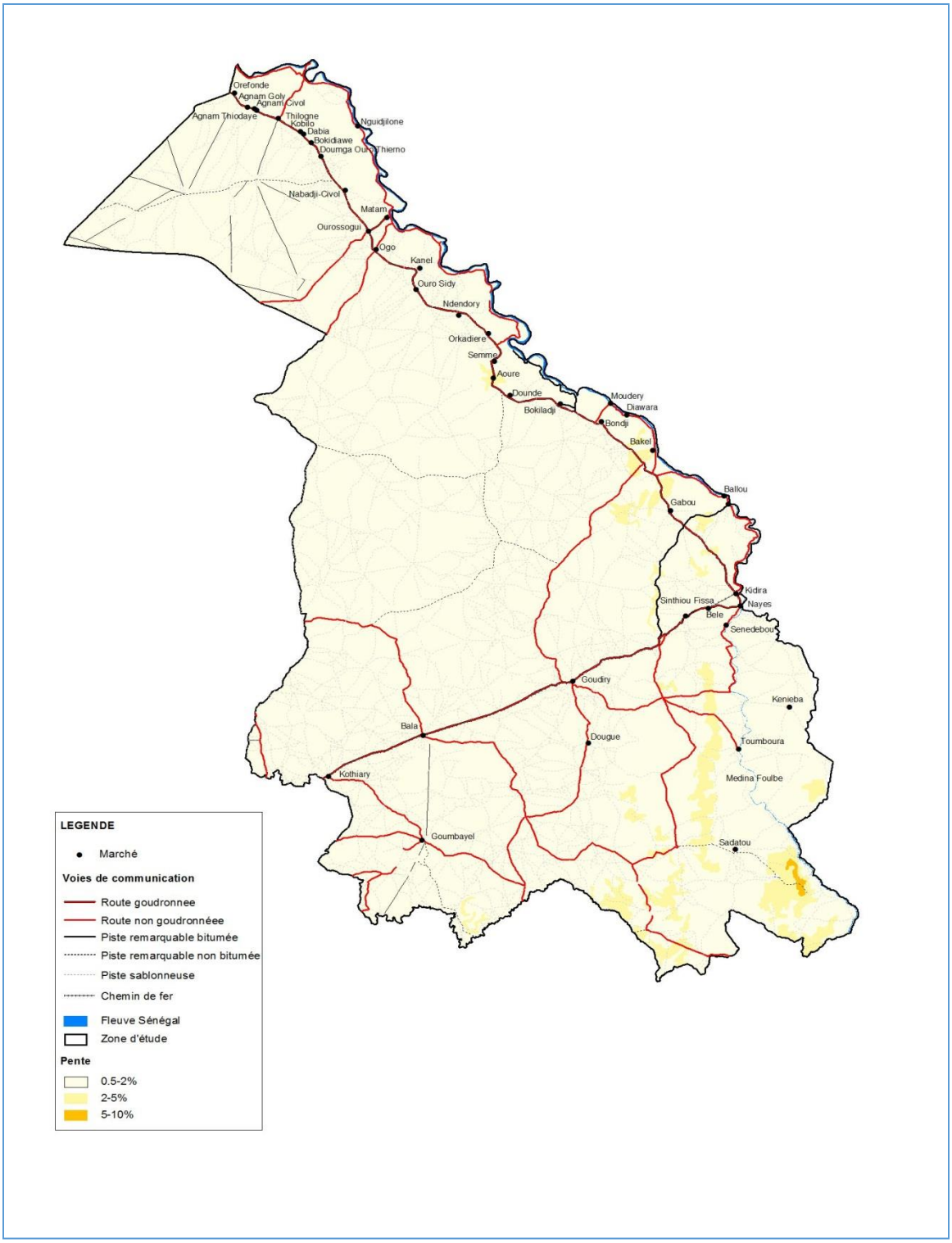

Figure 27: Valeur des pentes dans la zone d'étude

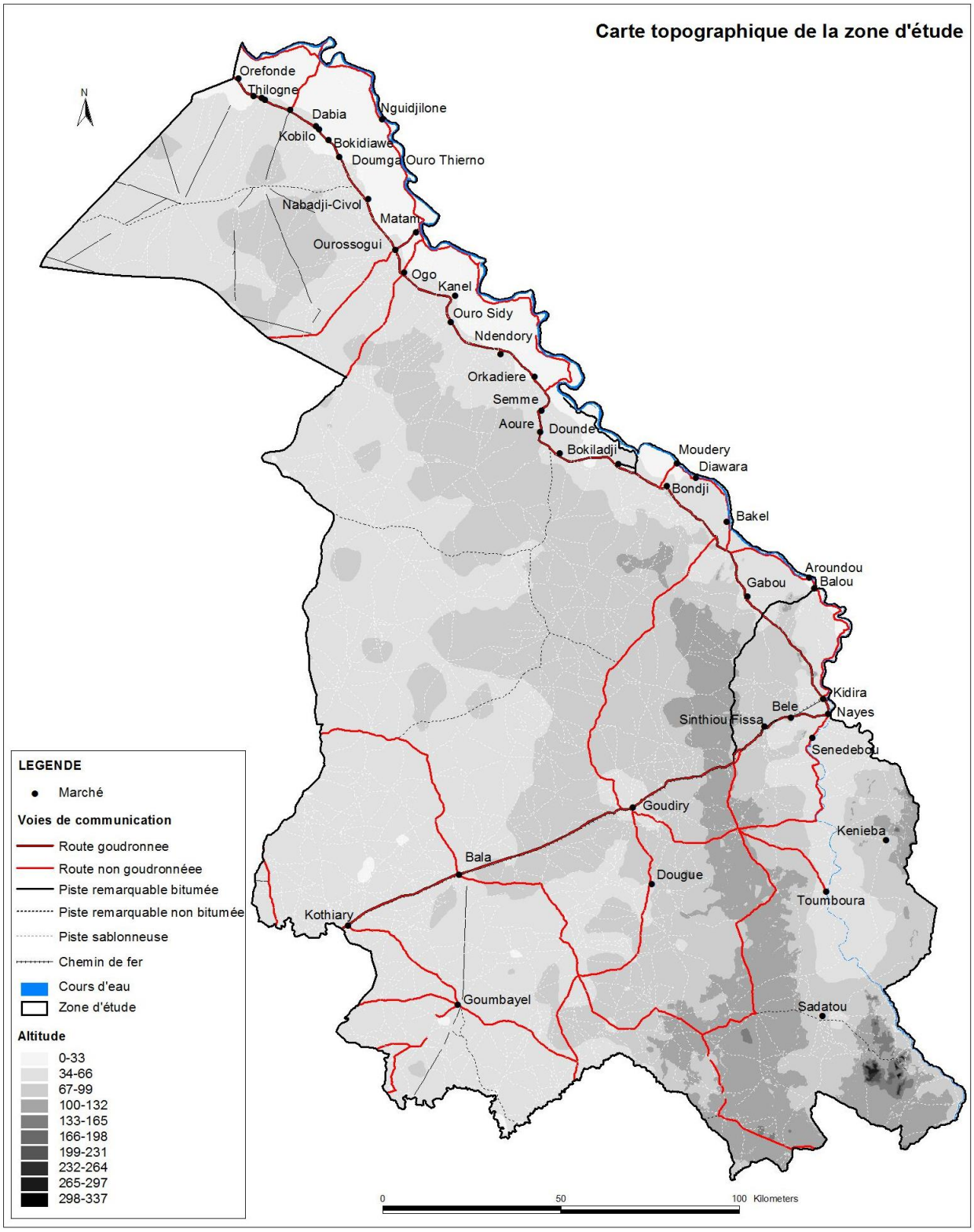

Figure 28: Carte topographique montrant les altitudes, avec les voies de communication

4.2.1.6 Les ressources hydrographiques

La superposition du MNT et du réseau hydrographique permet de localiser la ligne de partage des eaux, située au niveau de la dorsale qui apparaît dans le sud de la zone (Figure 28). Ce qui indique un sens de l'écoulement vers le fleuve *Sénégal* (frontière est). Cet état de fait a un impact sur l'accessibilité des marchés car les localités situées de part et d'autre de la dorsale sont confrontées au problème d'enclavement durant la saison des pluies en raison du remplissage de la multitude de vallées qui les traversent entravant la mobilité des personnes et des produits. Cela est encore plus préoccupant pour les localités sises dans la zone sud, entre le fleuve *Sénégal* et la *falémé,* ou qui bordent ce dernier cours d'eau. Malheureusement nous ne disposons pas d'une couche polygonale nous permettant de sélectionner les bassins versants des cours d'eau les plus importants pour évaluer leur influence sur l'accès au marché notamment en les croisant avec la couche des infrastructures routières. Cependant le sens de l'écoulement peut aider à sélectionner les localités qui sont les plus exposées au risque d'inondation.

4.2.1.7 Les ressources pédologiques

Les sols hydromorphes, halomorphes, et argileux (sols vertiques, sols peu évolués, sols bruns eutrophes) localisés dans des zones basses (vallées, cuvettes, bas de pentes, plateaux, plaines, etc.) occupent les zones inondables. L'utilisation de la couche morphopédologie nous permet de tenir compte à la fois de la topographie et de l'hydrographie. Cette variable permet de localiser les zones où il existe une menace sur les localités et les infrastructures (routes, ponts) en cas de forte pluviosité.

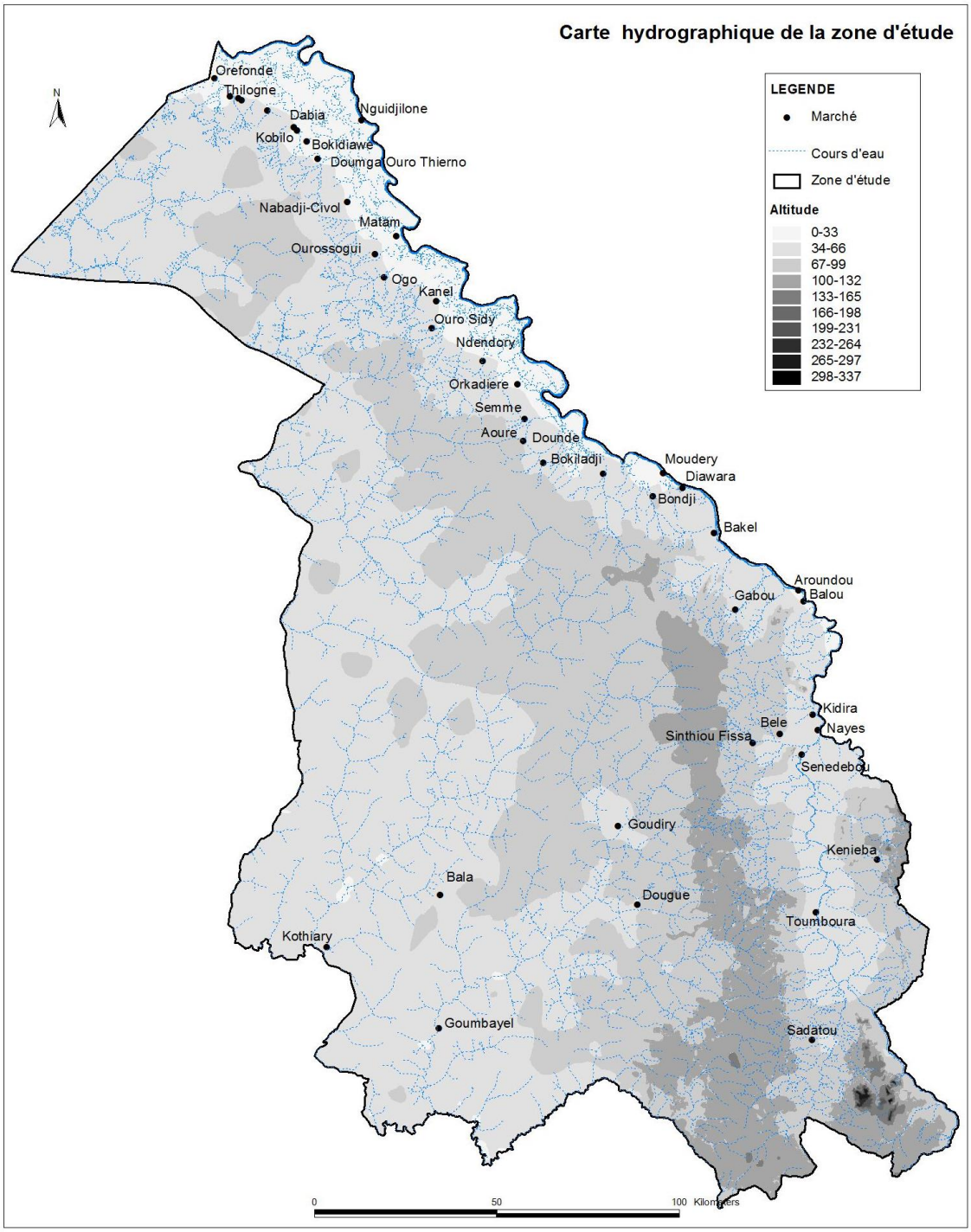

Figure 29: Carte hydrographique de la zone d'étude, avec les altitudes.

4.2.2 Analyse spatiale

4.2.2.1 Calcul des indices et classement selon la distance et les conditions physiques

La méthodologie utilisée consiste à faire recours à un indicateur pour permettre de déterminer le niveau d'accès aux marchés. Les variables « marché », « voies de communication », « topographie » et « morpho-pédologie » ont été classées dans une échelle commune binaire. Zéro représente une condition non favorable à l'accès au marché et 1, une condition favorable. Pour la variable « marché » le critère distance physique a été appliqué de même que pour la variable voie de communication. Toutefois pour cette dernière un second critère « praticabilité » a été ajouté à l'indice. Pour les variables « topographie » et morpho pédologie » elles ont été appréciées en tenant compte du critère « localisation ». A la fin, un indice composite d'accès a été calculé en faisant la somme des indices élémentaires (tableau 17).

Tableau 17: Calcul des indices

Indices élémentaires					**Indice composite**
Marché	***Voie de communication***		***Topographie***	***Morpho-Pédologie***	
Localité située à moins de 10 km du marché : 1	Localité située à -10 km : 1	Praticable : 1	Localité située dans une zone où l'altitude est inférieure à 100 m : 0	Localité située dans une zone basse et où le sol a un pouvoir de rétention d'eau élevé (sols hydromorphe, vertique, brun eutrophe, halomorphe ou peu évolué) : 0	*Somme des indices élémentaires*
Localité située à plus de 10 km du marché : 0	Localité située à plus de 10 km : 0	Non praticable : 0	Localité située dans une zone où l'altitude est supérieure à 100 m :1	Autre type de sol : 1	

4.2.2.2 Elaboration de la carte d'accès

L'indice composite a été par la suite interpolé en utilisant la commande « interpolate grid » de Arc View pour distinguer les zones où l'accès est très difficile, difficile, moyennement difficile et facile (figure 29). La combinaison des informations a donc permis d'identifier le niveau de vulnérabilité des localités situées dans la zone d'étude en terme d'accès au marché.

Le résultat de l'analyse spatiale montre que l'accès est très difficile pour les localités qui ont obtenu un score compris entre 0 et 1. C'est le cas au NE de Matam, de celles qui sont situées moins de 10 km de la R42 mais dans un rayon de plus 10 km des marchés. En outre, cette partie de la zone d'étude d'altitude très faible, est occupée par des sols peu évolués et des sols vertiques. Par contre la morphopédologie favorise l'inondation et l'enclavement des ménages durant la saison des pluies. Comme dans toute la vallée alluviale, le remplissage des vallées et des petits marigots rend la circulation impossible après les pluies. Cette situation pose le problème de l'approvisionnement en denrées alimentaires de première nécessité et en médicament, ou encore l'évacuation des malades en cas

d'urgence. De même elle entrave l'écoulement des produits agricoles (céréalicultures, riziculture, maraichage). Cependant, le fleuve représente une opportunité pour l'écoulement de la production de riz en Mauritanie.

L'accès est également très difficile pour les localités situées à l'ouest du département. Il s'agit en général de villages/hameaux d'éleveurs dépourvus d'infrastructures routières ou dotées de pistes non praticables et très éloignés des marchés. Cette situation est d'autant plus délicate que dans le département limitrophe à celui de Matam, Ranérou, est caractérisé par l'inexistence d'infrastructures routières bitumées. Cela freine l'activité commerciale notamment pendant l'hivernage. Les mouvements sont limités car les pistes sont quasi impraticables. Toutefois le bitumage de l'axe Linguère-Matam (RN3) qui vient d'être terminé cette année contribue au désenclavement de cette zone dont les populations ont l'habitude d'aller s'approvisionner dans les louma du département de Matam**.** L'accès s'améliore au fur et à mesure que l'on s'approche de la RN2.

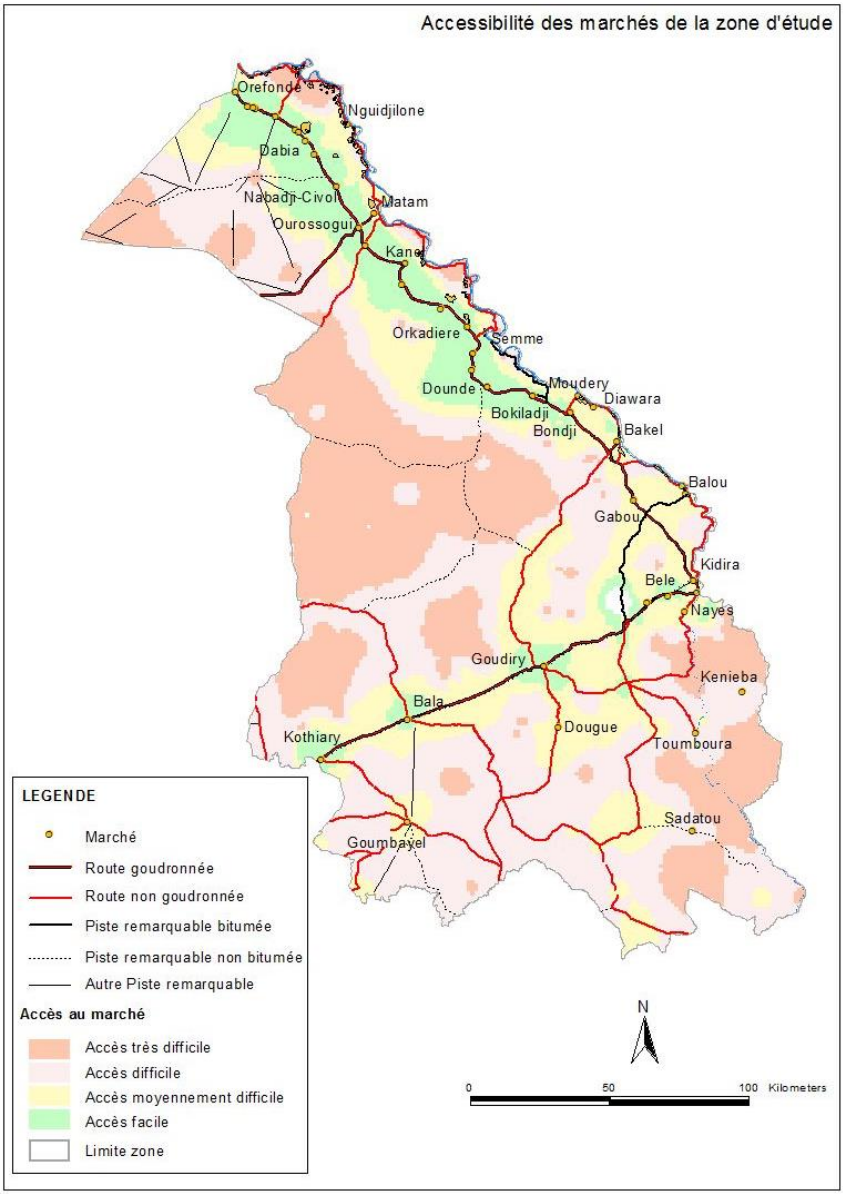

Figure 30: Accessibilité des marchés de la zone

Dans le sud de la zone les localités situées à moins de dix kilomètres des marchés quotidiens de Goudiry, Sinthiou Fissa, Bélé, Bala et Kothiary qui profitent de la RN1 accèdent facilement aux marchés (score 4). Dans le département de Bakel, hormis la partie nord-est, l'accès est difficile à cause de la distance aux marchés, du relief et de l'absence de voie de communication en bon état. Les villages de la poche de la Falémé dans le Bakel constituent les zones les plus enclavées de la région voire du Sénégal. Les pistes sont fréquemment coupées par les écoulements d'eaux de pluies. Les ponts s'effondrent régulièrement. L'absence de pistes de productions freine la valorisation des potentialités qu'offre le fleuve pour l'évacuation des productions vers les marchés des centres urbains. De ce fait les productions pourrissent et se détériorent. Cette situation est régulière dans les communautés rurales de Kéniéba, Balou et Gabou.

L'analyse spatiale a permis de localiser dans l'espace le niveau de vulnérabilité des localités de la zone d'étude par rapport à l'accès aux marchés. Toutefois l'information doit être enrichie et combinée aux variables sociodémographiques issues des enquêtes de terrain notamment en ce qui concerne la disponibilité et la circulation des produits (agro-pastoraux, forestiers, etc.), les mouvements de transhumance, etc. Les flux commerciaux sous-tendent les systèmes de vie et les mécanismes de survie des ménages vulnérables à l'insécurité alimentaire. Ils représentent des opportunités permettant aux ménages d'assurer leur sécurité alimentaire et de faire face aux crises.

Le déficit en matière d'infrastructures de désenclavement et le mauvais état des routes et pistes de production freinent le transfert des produits locaux vers les marchés porteurs.

Les marchés hebdomadaires de la zone d'étude sont enclavés pendant l'hivernage qui constitue la période de soudure. Cette situation exacerbe les difficultés saisonnières d'accès alimentaire des populations rurales. L'état souvent dégradé des routes augmente les coûts de transaction et les temps de transport.

Le déficit d'infrastructures, l'état impraticable des routes entrainent d'énormes pertes (méventes) des productions agricoles et des produits du bétail. Par ailleurs, la majorité des centres de production ne disposent pas d'infrastructures suffisantes de transformation, de conditionnement et de stockage de qualité obligeant les producteurs au bradage des productions en période de récolte. Dans la région de Tambacounda on mentionne des ruptures d'approvisionnement en vivres dans 65% des villages, (CSAO – CILSS 2008 Profil sécurité alimentaire Sénégal).

V- IMPACTS DES CHANGEMENTS CLIMATIQUES SUR L'ACCÈS AUX MARCHÉS POUR LES PÉRIODES 2030 ET 2050

5.1 PROJECTIONS CLIMATIQUES

Les projections climatiques portent sur deux variables : la pluviométrie et la température. De même trois (3) scénarii sont envisagés (sec, normal et humide).

Dans le cas du scénario *sec* 2030, on note une diminution générale de la pluviométrie avec des totaux inférieurs à 550 mm à l'exception de la zone située autour de Goudiry où elle peut atteindre 650 mm. En revanche, dans le cas d'un scénario *normal* à *humide*, si la tendance reste la même dans la zone nord (baisse des précipitations), le sud enregistre une rémission avec des précipitations pouvant atteindre 750 mm autour de Goudiry et Bakel (figure 30).

A l'horizon 2050, aussi bien pour le scenario *sec* que *normal*, la pluviométrie pourrait baisser dans toute la zone d'étude avec des totaux inférieurs à 550 mm sauf sur la frange sud-ouest où elle pourrait atteindre 650 mm (figure 30).

Considérant le scenario humide (2050), dans la zone nord, la moitié sud du département de Kanel pourrait enregistrer une une amélioration des cumuls pluviométriques (entre 550 et 850 mm selon un gradient nord-est/sud-ouest). Dans la zone sud, il faudrait noter une augmentation des précipitations dans la moitié ouest du département de Goudiry. Cependant, une poche déficitaire est notée entre Goudiry et Bakel (figure 30).

A propos de la température, tous les scénarii montrent une hausse généralisée dans la zone d'étude quelles que soient les périodes 2030 et 2050 (figure 31).

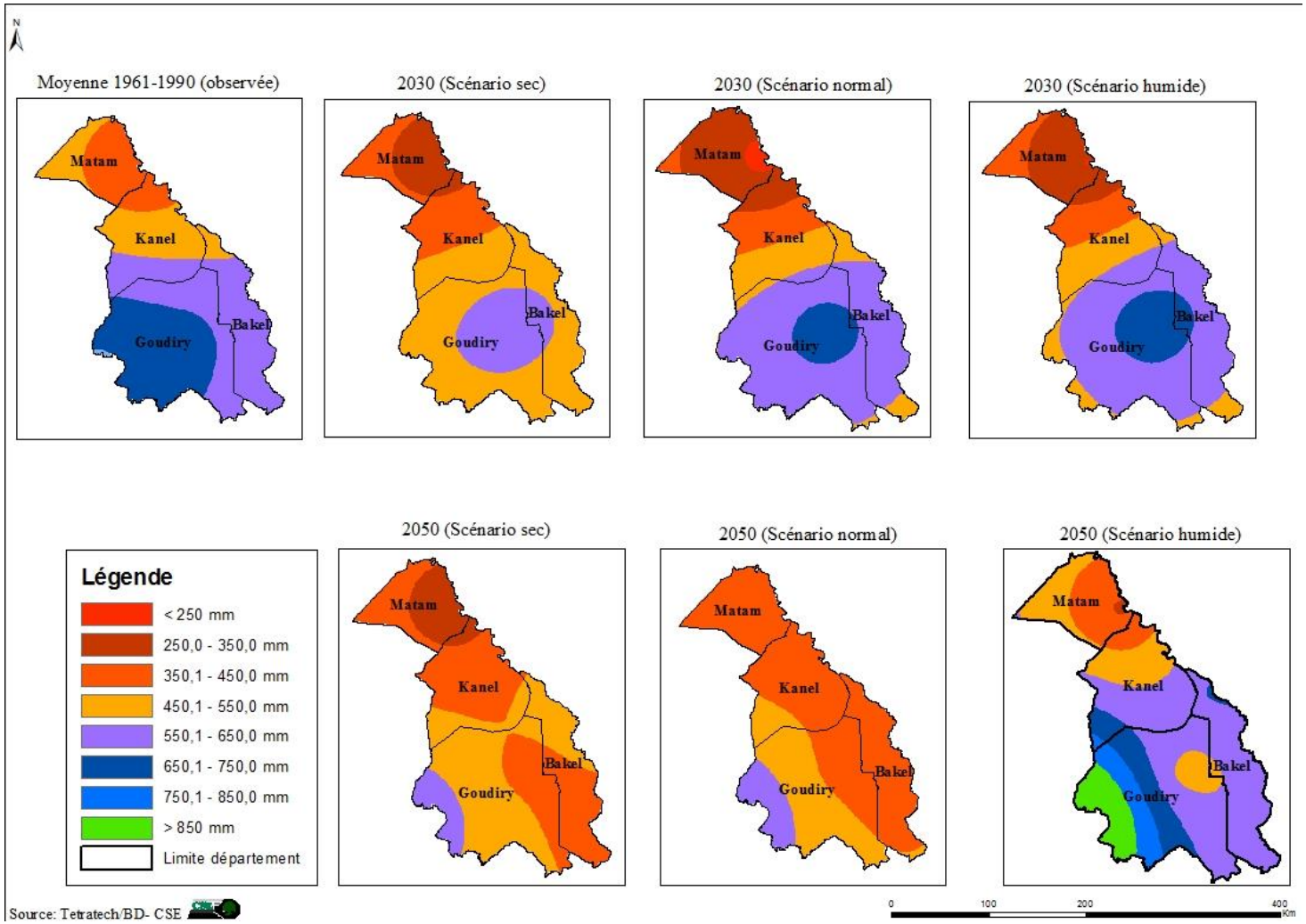

Figure 31: Projection de la pluviométrie dans la zone d'étude pour 2030 et 2050

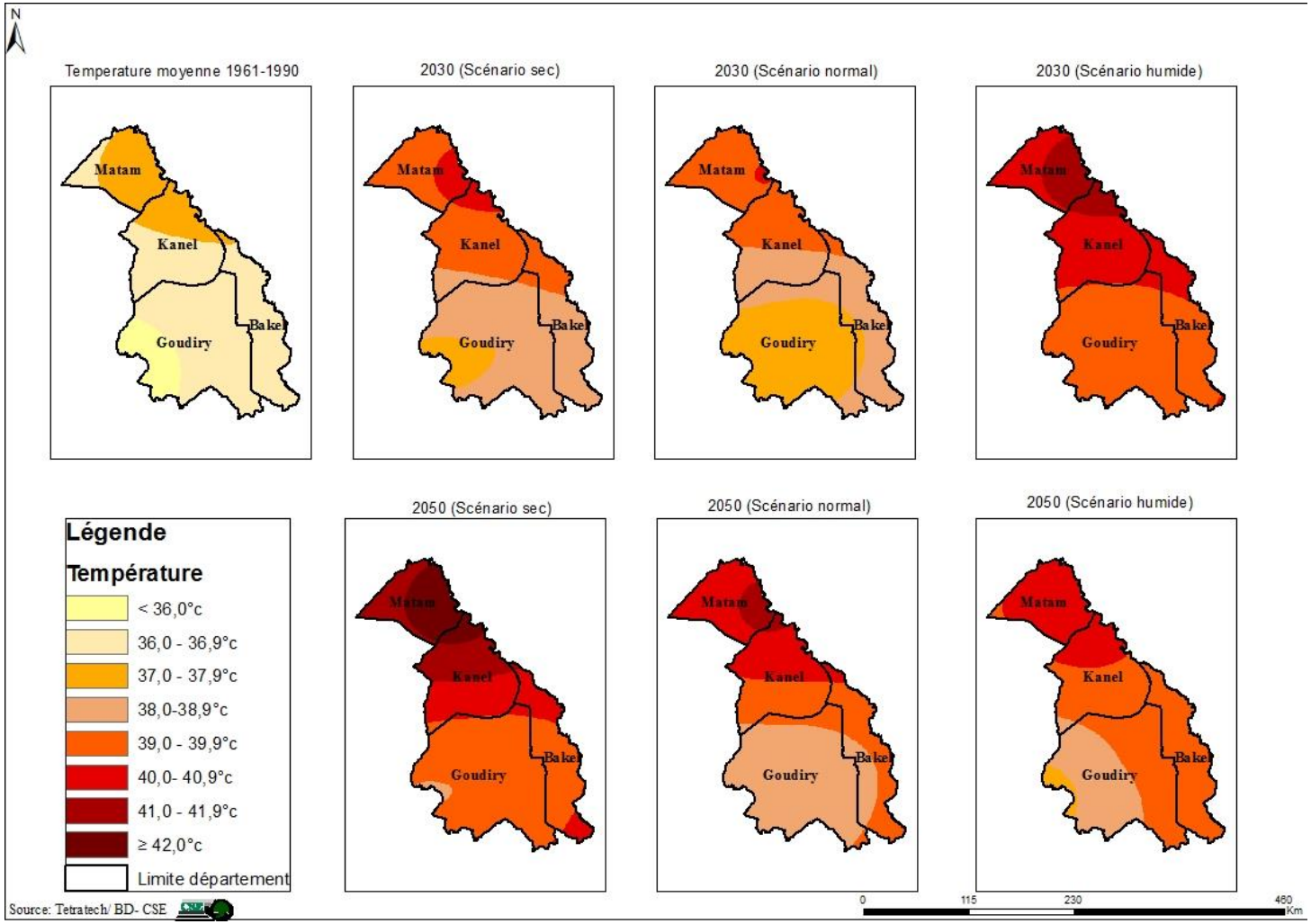

Figure 32: Projection de la température dans la zone d'étude pour 2030 et 2050

5.2 IMPACTS SUR L'ACCÈS AUX MARCHÉS

5.2.1 Impacts sur la disponibilité du produit

Dans la zone d'étude, les productions vivrières, principaux moyens de subsistance des ménages, sont très dépendantes de la pluviométrie. Les marchés assurent un service socio-économique de base important pour la sécurité alimentaire des populations.

Dans le cadre des changements climatiques, la baisse de la pluviométrie prévue dans le scénario sec 2030 et dans les scénarii secs et humide 2050 entrainerait un déficit de production vivrière. Ainsi, face au déficit structurel de produits vivriers qui provoque la forte dépendance aux marchés, le changement climatique pourrait augmenter le besoin en service d'approvisionnement des populations, fourni par les marchés. Ceci pourrait donc accentuer l'importance des marchés pour la sécurité alimentaire.

De même, l'inondation des rizières, même si la production locale de riz ne prend pas encore en charge les besoins, pourrait constituer un autre facteur du risque si l'on essaie de développer la riziculture dans le cadre des programmes de résilience. Cet aspect serait valable uniquement pour le département de Kanel dans le cas du scenario humide 2050.

Les principaux facteurs de vulnérabilité des systèmes pastoraux sont l'accessibilité et la disponibilité des ressources en eau et en pâturage. La baisse des précipitations provoquera à son tour celle de la productivité des pâturages et de la quantité des eaux de surface (situation de la projection 2050, cas des scenarii sec et normal). Cela impliquerait une diminution des revenus des communautés qui contribuera sans nul doute à réduire l'accès économique au marché. La réduction de la productivité du cheptel va fortement réduire la capacité du ménage pastoral à accéder au marché compte-tenu de l'importance de la contribution du bétail dans les moyens de subsistance.

La décomposition du risque permet aussi de voir la part des feux de brousse qui affectent beaucoup les productions forestières et le cheptel. Les productions forestières moins sensibles à la variabilité pluviométrique subissent plutôt la pression anthropique avec les feux de brousse et l'émondage excessif pratiqué dans la zone d'étude par les éleveurs. Le cheptel aussi est souvent confronté au déficit fourrager dû à ces feux causés en grande partie par les communautés locales ou les transhumants.

5.2.2 Impacts sur l'accessibilité

Dans la zone sud, la rémittence de la pluviométrie dans les scénarii normal et humide 2030 et son augmentation dans le scénario humide 2050 pourraient aggraver l'état de dégradation de la voirie, à travers une éventuelle augmentation des événements météorologiques et climatiques extrêmes (inondations, hausse des températures, vents violents, etc.). Ce qui accentuera le problème de l'enclavement des localités et la précarisation des ménages en raison de l'inaccessibilité des marchés. Cette situation sera plus grave dans le département de Bakel où l'enclavement est plus accentué en raison de la combinaison des facteurs physiques (nature des sols, relief encaissé, présence de nombreuses vallées) et structurelles (mauvais état de la voirie).

La hausse des températures, tout comme celle de la pluviométrie, accentuera, en l'absence de travaux de réhabilitation de grande envergure, l'état de dégradation des voies de communication.

En outre, les phénomènes extrêmes liés à la variabilité climatique (inondation, hausse des températures) vont accroitre le besoin en investissement pour l'entretien des infrastructures routières dans la zone d'étude.

CONCLUSION ET RECOMMANDATIONS

La zone d'étude offre d'importantes opportunités agro-pastorales qui avec des investissements conséquent pourraient aider à réduire la vulnérabilité des ménages qui y vivent. Il s'agit de la diversification des spéculations agricoles (surtout dans le nord où trois types de culture sont pratiquées : sous pluie, de décrue et irriguée), de l'importance des productions animales, de la situation géographique transfrontalière des marchés qui permet d'accéder aux produits de la sous-région comme le mil et le maïs du Mali, de la présence de marchés et de l'existence de voies de communication. Les ressources végétales jouent un rôle important surtout dans la partie sud où l'exploitation forestière génère d'importants revenus.

Toutefois, le changement climatique combiné aux pratiques de gestion irrationnelle des ressources naturelles (feu, élagage, etc.) menacent les moyens de subsistance des ménages comme en atteste la disparition des peuplements de *Sterculia Setigera* à partir desquels le Sénégal produisait de la gomme se positionnant au premier rang sur le plan international.

L'accès au marché est freiné par leur mauvaise répartition dans l'espace. Ils se concentrent le long des principales voies de communication alors que la majorité des populations pastorales vivent dans les zones où le pâturage est abondant et autour des mares de la saison des pluies à des distances éloignées. S'y ajoute le mauvais état de la voierie.

L'étude a montré aussi que la production vivrière est déficitaire dans la zone d'étude. Les marchés jouent donc un rôle important dans l'approvisionnement des ménages en céréales, base de l'alimentation locale. L'impact du changement climatique sur ces marchés pourrait donc résider, en partie, dans l'accroissement de la demande des populations (fonction des marchés) pour un approvisionnement correct permettant de parer à l'effet du changement climatique sur les productions en cas de baisse de la pluviométrie surtout. Une dépendance accrue va donc exiger beaucoup plus d'investissements pour des marchés fonctionnels et accessibles. L'analyse de l'accès physique aux marchés montre que le faible niveau d'équipement en voies de communication est un facteur limitant majeur. Aussi, les marchés qui seront de plus en plus sollicités, devront faire l'objet d'une attention particulière dans la politique de développement de la zone.

Les options d'investissement pour développer les capacités de résilience des ménages au changement climatique devront être orientées vers :

- le développement et l'amélioration de l'infrastructure physique : meilleure répartition spatiale de marchés, réduction de la distance physique au marché
- la recherche de solutions alternatives pour les échanges commerciaux au cours de la saison des pluies avec notamment le développement du transport fluvial.
- l'amélioration de la densité et de la praticabilité du réseau routier avec notamment l'aménagement de pistes de production;
- la prise en compte de la variabilité climatique et des phénomènes extrêmes associés dans la conception et les travaux de dimensionnement des infrastructures (routes, ponts, points d'eaux) ;
- l'atténuation de la dépendance grandissante des ménages aux marchés en renforçant la résilience à travers les systèmes de production (agriculture, élevage, forêt et irrigation) :

- identification et adoption de variétés culturales adaptées,
- développement de la culture irriguée dans la vallée du fleuve,
- technique de gestion rationnelle des ressources forestières,
- le développement de filières de produits forestiers non ligneux,
- valorisation des sous –produits de l'élevage ,

- la mise en place de système d'alerte précoce capable de renforcer la résilience au niveau des communautés et des infrastructures.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES L – M

SEPTEMBER 2014

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ARCC

African and Latin American
Resilience to Climate Change Project

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ANNEX L. EVALUATION DE LA VULNERABILITE AUX CHANGEMENTS CLIMATIQUES AU SENEGAL ET ANALYSE DES OPTIONS

EVALUATION DE LA VULNERABILITE AUX CHANGEMENTS CLIMATIQUES AU SÉNÉGAL ET ANALYSE DES SOLUTIONS :

Synthèse des travaux de recherches et de vulgarisation dans le domaine de l'agriculture et des CC

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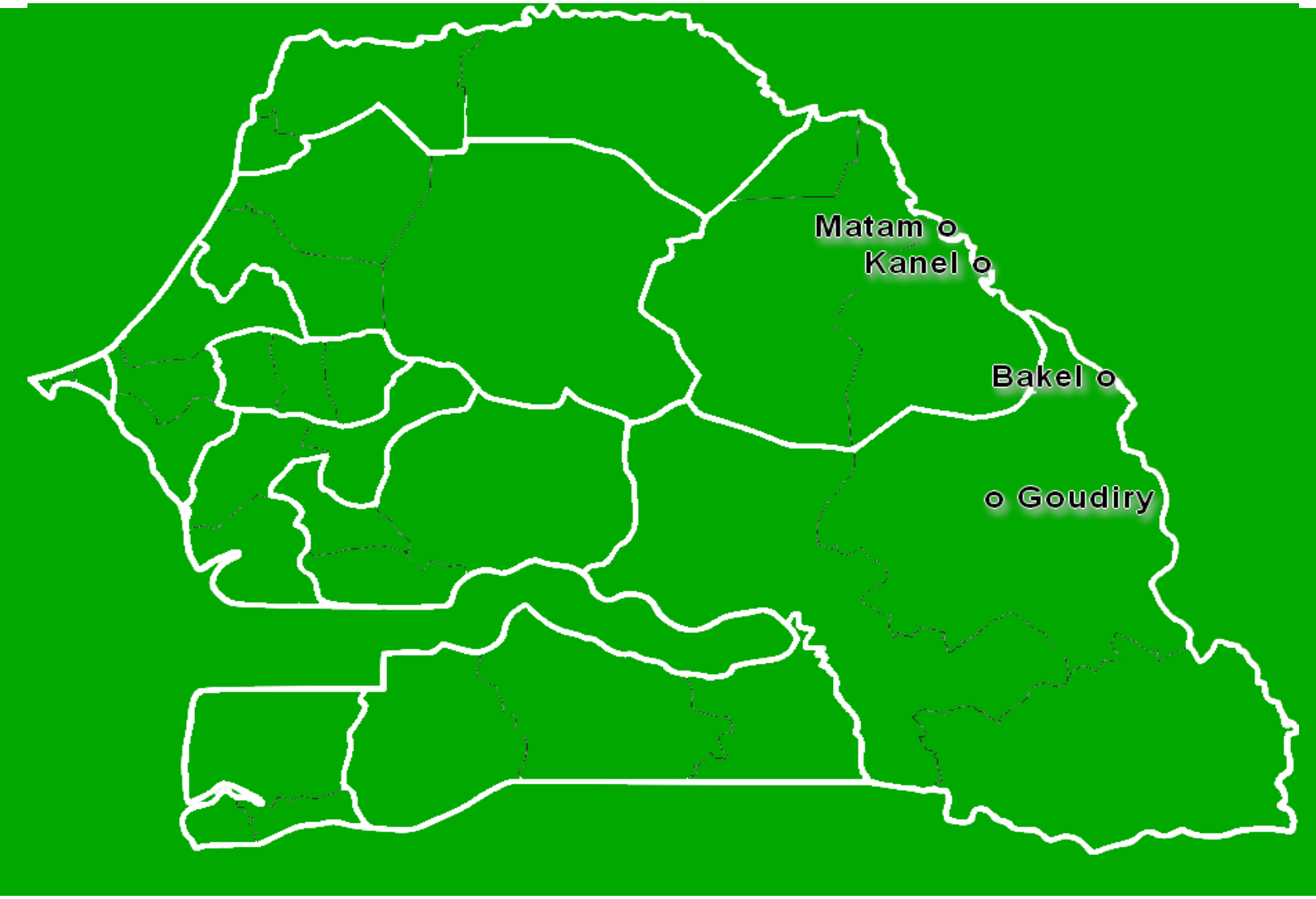
Août 2013



EXECUTIVE SUMMARY (English)

As part of the *African and Latin American Resilience to Climate Change* (ARCC) project, USAID is studying the vulnerability of local communities and strategies to support climate change adaptation in Senegal. In this context, ARCC is assessing the impact of climate change on populations and resources in order to propose adaptation strategies. The assessment will help USAID/Senegal better understand the actual threat of climate change to vulnerable populations and ecosystems in order to develop adaptation strategies and identify investment opportunities for its development programs, specifically for the agricultural sector, as part of the "Feed the Future" program.

The ARCC assessment in Senegal focuses on portions of the Matam and Tambacounda regions. It will identify vulnerabilities, as well as the technologies, practices, and reforms that must be implemented in the priority sectors of agriculture and animal husbandry in order to reduce vulnerability to climate change. Its overall goal is to contribute to sustainable development in the study zone. This region of Senegal shows a high degree of vulnerability and food insecurity (PAM, 2010).

A bibliographic review and scoping meeting on general methodology enabled us to develop the summary document and formulate recommendations in the fields of research and general information for better adaptation to climate change. The study allowed us to present an overview of the technologies and practices in place in the regions of Matam and Tambacounda.

It must be noted that research was previously conducted in Senegal following the drought of the 1970s; it generally concerned varietal adaptation to drought. It was conducted on a national scale, but it took into account the uniqueness of each region for the distribution of varietals. This research focused on various cultivated crops, taking hydric, agroclimatic, and edaphic factors into account, in order to develop the most resistant and best adapted varieties to the local environment.

Other studies have focused on improving process management, performance modelling, and, most recently, irrigation simulation for the purpose of optimizing the management of irrigation water.

Research conducted on forest resources generated numerous technologies. However, as is the case in other fields, the results of the research and its appropriation by end users still remain weak. In order to better adopt the technologies, certain inherent barriers to distribution must be eliminated.

A NUMBER OF THE PROPOSED SOLUTIONS ARE ESSENTIAL, SUCH AS SUPPORT FOR RURAL ORGANIZATIONS AND THEIR INVOLVEMENT IN DECISION MAKING, WHICH REQUIRES A REINFORCEMENT OF THEIR SKILLS; PROMOTION OF A GENDER-BASED APPROACH, AND THE INVOLVEMENT OF WOMEN IN MAKING DECISIONS; INCREASING THE PROFESSIONAL SKILLS OF KEY ACTORS, ESPECIALLY BREEDERS; STRENGTHENING THE SKILLS OF AGENTS RESPONSIBLE FOR DISSEMINATING GENERAL INFORMATION; AND PROMOTING PARTICIPATORY ACTION RESEARCH.

Communication through awareness-raising and knowledge-sharing also contributes to the proper management of natural resources and improving the lives of rural populations.

RESUME EXECUTIF

L'USAID à travers le projet « *The African and Latin American Résilience to Climate Change* » (ARCC) étudie la vulnérabilité des communautés de base et les stratégies d'adaptation et de développement durable au Sénégal. Ainsi le programme ARCC s'intéresse à l'évaluation de l'impact des changements climatiques sur les populations et les ressources afin de proposer des stratégies d'adaptation. Le projet permettra de mieux orienter les missions de l'USAID en : i) évaluant les menaces réelles des changements climatiques et leurs impacts sur les populations et les écosystèmes vulnérables ; ii) préparant des stratégies d'adaptation ; iii) et en programmant des fonds essentiel (USG) pour les programmes de croissance économique en particulier pour le secteur de l'agriculture dans le cadre du programme « Feed the Future ».

Il vise à évaluer la vulnérabilité des régions de Matam et de Tambacounda au changement climatique et l'analyse des options d'adaptation pour un développement durable de ces zones. L'étude cherche ainsi à identifier la vulnérabilité, les technologies, pratiques et réformes devant être mises en œuvre dans les secteurs prioritaires de l'agriculture et de l'élevage, pour réduire les émissions des GES et la vulnérabilité aux changements climatiques et contribuer aux objectifs de développement durable dans les régions de Matam et de Tambacounda. Ces deux régions du Sénégal enregistrent un niveau élevé de vulnérabilité et d'insécurité alimentaire (PAM, 2010).

Cette présente étude entre dans le cadre du projet ARCC et évalue la synthèse des travaux de recherches et de vulgarisation dans le domaine des changements climatiques au Sénégal et plus spécifiquement dans les zones d'étude de Matam et Tamba.

Une revue bibliographique et une réunion de cadrage sur la méthodologie général, nous a permis d'élaborer le document de synthèse et de formuler des recommandations sur les domaines de la recherche et de la vulgarisation pour une meilleure adaptation aux changements climatiques.

Ainsi l'étude a permis de synthétiser les technologies et pratiques en cours dans les régions de Matam et Tambacounda qui sont caractérisées par un niveau élevé de vulnérabilité et d'insécurité alimentaire (PAM, 2010).

Ainsi on note que des recherches ont été menées au Sénégal à la suite de la sécheresse des années 70, et ont généralement porté sur l'adaptation variétale à la sécheresse. Ces recherches de création et d'adaptation variétales se sont effectués au niveau national, mais en tenant compte de la spécificité de chaque zone pour la diffusion des variétés (exemple la carte variétale de l'arachide). Ces recherches ont concernées diverses spéculations cultivées en tenant compte de facteurs hydriques, agroclimatiques et édaphiques afin de mettre au point des variétés résistantes et adaptées au contexte local.

D'autres études ont portées sur l'amélioration de la gestion des parcours, la modélisation des rendements et tout récemment sur la simulation de l'irrigation pour une optimisation de la gestion des eaux d'irrigation.

L'action anthropique a accentué ce phénomène de la vulnérabilité avec une surexploitation des ressources naturelles.

Les recherches faites sur les ressources forestières ont générées de nombreuses technologies. Mais comme dans les autres domaines, a vulgarisation de la recherche et son appropriation par les utilisateurs finaux restent encore faible.

Ainsi pour une meilleure adoption des technologies, il est nécessaire de lever certaines barrières inhérentes à la diffusion.

PARMI LES SOLUTIONS PROPOSEES, CERTAINES D'ENTRE ELLES SONT INDISPENSABLES COMME : I) L'APPUI AUX ORGANISATIONS PAYSANNES ET LEUR IMPLICATION DANS LES PRISES DE DECISION, CE QUI NECESSITE UN RENFORÇANT DE LEUR CAPACITES ; II) LA PROMOTION DE L'APPROCHE GENRE ET LEUR IMPLICATION DANS LES POUVOIRS DE DECISIONS ; LA PROFESSIONNALISATION DES ACTEURS SURTOUT DES ELEVEURS ; LE RENFORCEMENT DE CAPACITE DES AGENTS DE VULGARISATION ; LA PROMOTION DE LA RECHERCHE ACTION PARTICIPATIVE.

La communication par la sensibilisation et le partage des savoirs participe également d'une bonne gestion des ressources naturelles et à l'amélioration de la vie des populations rurales.

1. CONTEXTE

Le Sénégal figure parmi les pays les moins avancés (PMA), avec un faible Indice de Développement Humain (IDH, classement PNUD 2005 : 157/173). Et selon le Groupe Intergouvernemental des Expert du Climat (GIEC), les pays les moins avancés ont et auront des difficultés techniques et financières pour faire face aux variations climatiques et à leurs impacts, en raison de leur niveau faible de développement. Ces pays sont considérés par les Parties à la CCNUCC comme étant parmi les pays les plus vulnérables aux changements climatiques. Ainsi ces changements impacteront fortement sur les économies, de ces pays qui sont pour la plupart africains (IPCC, 2003). La vulnérabilité de ces pays et leurs capacités d'adaptation dépendra fortement de leurs capacités techniques, du rôle des parties prenantes dans la planification du développement national et des transferts de technologies appropriées pour un développement durable.

Pour accompagner les pays en développement dont le Sénégal, le gouvernement américain à travers l'USAID et l'USDA met en œuvre des projets et programmes de recherches et de développement dans les secteurs de l'agriculture, de l'élevage et de la gestion des ressources naturelles (projet Wula Nafaa ; Clusa ; Projet de croissance économique, Programme ERA etc). Afin de mener à bien ces programmes, l'USAID s'appuie sur le projet ARCC « The African and Latin American Resilience to Climate Change » pour investir plus efficacement et de manière cohérente dans les activités de programmation d'adaptation et les activités qui soutiennent la croissance économique.

Le projet « ARCC» étudie la résilience aux changements climatiques de certains pays Africains. Il permettra de mieux orienter les missions de l'USAID en : i) évaluant les menaces réelles des changements climatiques et leurs impacts sur les populations et les écosystèmes vulnérables ; ii) préparant des stratégies d'adaptation ; iii) et en programmant des fonds essentiel (USG) pour les programmes de croissance économique en particulier pour le secteur de l'agriculture dans le cadre du programme « Feed the Future »

Il vise à évaluer la vulnérabilité du Sénégal au changement climatique et l'analyse des options d'adaptation et d'atténuation des émissions de GES. L'étude cherche ainsi à identifier la vulnérabilité, les technologies, pratiques et réformes devant être mises en œuvre dans les secteurs prioritaires de l'agriculture et de l'élevage, pour réduire les émissions des GES et la vulnérabilité aux changements climatiques et contribuer aux objectifs de développement durable dans les régions de Matam et de Tambacounda. Ces deux régions du Sénégal enregistrent un niveau élevé de vulnérabilité et d'insécurité alimentaire (PAM, 2010).

Le présent rapport fait référence à l'étude sur les opportunités de recherche et de vulgarisation développées ou à développer. Il s'agit de faire l'état des lieux sur le potentiel des nouvelles technologies et pratiques à développer et à vulgariser pour les producteurs ruraux afin de réduire les impacts potentiels du changement climatique dans la zone d'étude. Il s'agira aussi de décrire l'état actuel de la recherche et du transfert de technologies agricoles, de tirer les leçons des expériences réalisées au Sénégal et de mettre l'accent sur les meilleures pratiques et perspectives futures à développer. L'étude se focalise spécifiquement sur les programmes ayant trait à:

- L'amélioration de la gestion des parcours;
- La promotion de l'intégration de l'élevage dans les systèmes de culture ;

- L'accès à de nouvelles variétés ;
- La promotion de nouvelles pratiques culturales ;
- La prévention et la gestion des risques liées au Climat ;
- L'amélioration de l'exploitation des ressources naturelles
- La promotion des technologies
- Et la promotion de la bonne gouvernance des ressources naturelles.

2. BREVES INTRODUCTION SUR LE CONTEXTE NATIONAL

2.1. Informations géographiques

Le Sénégal est situé à l'extrémité Ouest du continent africain, entre les latitudes 12°00 et 16°30 Nord et les longitudes 11°30 et 17°30 Ouest. Il s'étend sur une superficie de 196 722 kilomètres carrés. Il est frontalier de la Mauritanie au Nord, du Mali à l'Est, de la Guinée Conakry au Sud-est et de la Guinée Bissau au Sud-ouest. La Gambie constitue une enclave de 11.300 km² dans la partie Sud du Sénégal. La façade maritime du pays s'étend sur plus de 700 km et couvre une bande côtière allant du Sud au Nord du pays.

Le territoire national est divisé en 14 régions administratives depuis 2008 (Dakar, Diourbel, Fatick, Kaffrine, Kaolack, Kolda, Kédougou, Matam, Saint Louis, Sédhiou, Tambacounda, Thiès, Ziguinchor), elles-mêmes subdivisées en départements et arrondissements.

Le relief est plat dans son ensemble exception faite des zones structurales et du socle précambrien. En dehors de la région orientale, présentant des altitudes supérieures à 500 m (581 m au point culminant des contreforts du Fouta Djalon), l'ensemble du territoire sénégalais se situe sous l'altitude des 130 m.

Le climat est de type Soudano-sahélien, caractérisé par l'alternance d'une saison sèche allant de novembre à mai et d'une saison des pluies allant de juin à octobre. La pluviométrie moyenne annuelle suit un gradient Nord-Sud, allant de 300 mm à 1500 mm. Le climat est soumis à la fois à des facteurs géographiques et des influences atmosphériques. Aussi, la présence d'une façade maritime de 700 Km entraîne des différences climatiques entre la zone côtière et les régions de l'intérieur. La péjoration du climat et plus particulièrement le déficit pluviométrique est marqué par le glissement progressif des isohyètes vers le sud (figure 1).

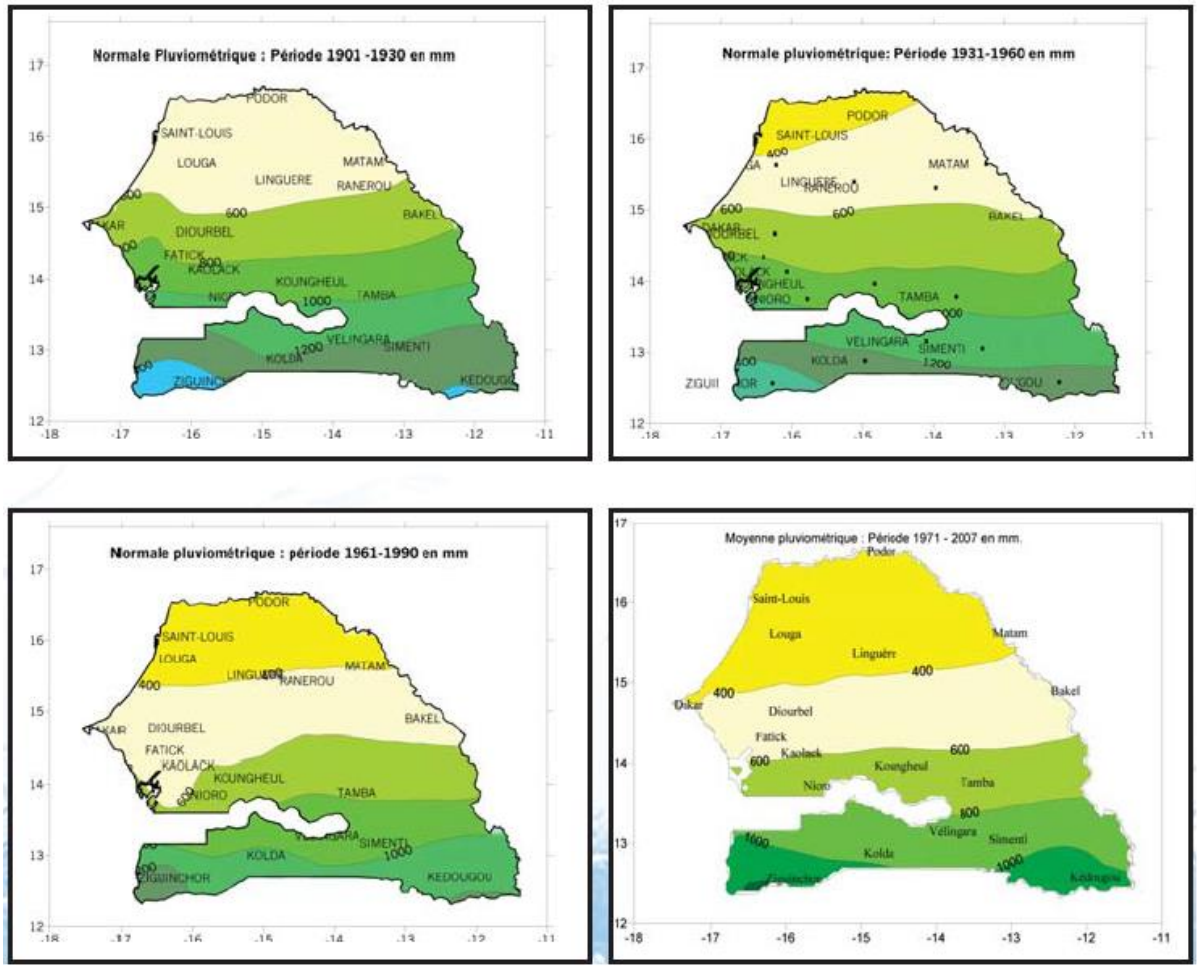


Figure 1: Evolution des isohyètes de 1901 à 2007

Au plan thermique, il existe une différence bien marquée entre le domaine littoral, aux températures douces (moyenne thermique 25 °C) et le domaine continental, chaud (moyenne centré sur 30 °C) et sec avec de grands écarts thermiques. L'évolution des températures à Matam, localité du nord-est à climat chaud et sec, est relativement constante de 1941 à 1970 pour subir à partir de la décennie 1971-80 une hausse assez remarquable en fin de siècle.

Sur la base des modèles, deux scénarii différents ont été simulés. Pour le premier scénario, les auteurs ont prévu une augmentation de la température de 1,5 °C combinée à une baisse de la pluviométrie de 8,5 % et, pour le second, la même augmentation de température est combinée à une baisse de la pluviométrie de 17 %.

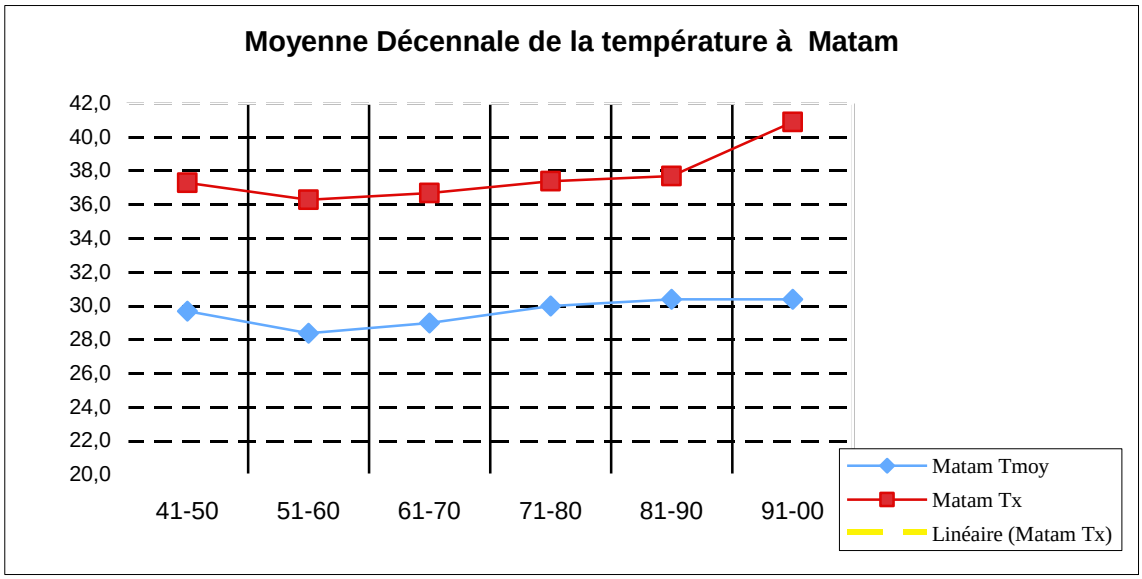


Figure 2: Moyennes décennales des températures dans la région de Matam

Sur le plan hydrologique, le pays dispose d'un réseau hydrographique important représenté par les principaux fleuves Sénégal (1700 km), Gambie (850 km), qui prennent leurs sources dans les massifs du Fouta Djalon en Guinée. Le fleuve Sine Saloum et le fleuve Casamance sont des cours d'eau côtiers. Ces ressources sont estimées à des dizaines de milliards de m3 de réserves et offrent d'importantes opportunités de développement agro-sylvo-pastoral avec des possibilités d'irrigation estimées à 240.000 ha dans la vallée du fleuve Sénégal (Ndiaye, 2007). Cependant elles sont fortement dépendantes de la variabilité de la pluviométrie (Ndiaye, 2007).

2.2. La Population

La population du Sénégal était évaluée à 9 858 482 habitants en 2002 et à environ 13 Millions d'habitants en 2012. Le taux d'accroissement moyen annuel de la population est passé de 2,3% entre 1960 et 1970 à 2,7% pour la période 1976-1988. Cette augmentation reflète ainsi la baisse de la mortalité au cours des trente dernières années, dont l'effet a été amoindri par la natalité assez importante, en milieu urbain comme en milieu rural.

La population du Sénégal demeure très inégalement répartie dans l'espace avec une densité moyenne au kilomètre carré de 50 habitants qui présente un minimum de 10 au Sud Est du pays et un maximum de 3964 habitants à Dakar, région abritant la capitale administrative et économique.

2.3. L'économie

La situation socio-économique du Sénégal est marquée par une croissance disproportionnée entre la démographie et l'économie. L'économie du pays repose principalement sur les activités du secteur primaire (l'agriculture, l'élevage et la forêt). Ce secteur a enregistré une croissance de 12,2% en 2005 contre 2,7% en 2004, essentiellement tirée par le sous-secteur agricole. Durant la période 2000-2011 le taux de croissance du PIB du Sénégal s'est établi en moyenne annuelle à 3,9%, un ratio au-dessus du taux de croissance démographique annuel (2,6%). Cette performance, inférieure à celle observée entre 1995

et 2005 (en moyenne 5%), résulterait, en partie, des chocs exogènes consécutifs aux crises alimentaires et financières connues ces dernières années.

Les objectifs économiques et financiers à moyen et long terme continuent à viser la réalisation des objectifs intermédiaires de développement du millénaire et la satisfaction de la demande sociale. Les différents axes d'intervention continueront de s'articuler autour des orientations de la Stratégie de Réduction de la Pauvreté (SRP) et de la Stratégie de Croissance Accélérée (SCA) qui consiste à faire du Sénégal un pays émergent. La SCA vise essentiellement :

(i) une accélération de la croissance économique, par une amélioration qualitative de la structure de l'économie pour la rendre plus efficace dans la lutte contre la pauvreté et ;

(ii) une diversification des sources de la croissance pour la sécuriser et la pérenniser afin de porter, le taux de croissance réel du PIB à moyen et long terme à plus de 7% en moyenne annuelle.

2.4. L'agriculture

L'agriculture sénégalaise constitue la base de l'économie du pays. Elle occupe environ 60 à 70% de la population active et contribue à hauteur de 10% à 11% au PIB national (PGIES, 2002). Les activités agricoles constituent une base importante pour la disponibilité alimentaire. Les sous-secteurs (agriculture, élevage et pêche) jouent un rôle extrêmement important pour l'accès à l'alimentation des populations urbaines et rurales du pays car, mise à part l'autoconsommation supportée par les cultures vivrières, les revenus dépendent fortement de l'agriculture commerciale en milieu rural.

L'essentiel des superficies est dominé par les cultures pluviales, avec 96 % des surfaces cultivées. Cette agriculture pluviale, de nature particulièrement extensive, repose essentiellement sur l'activité des petites exploitations familiales qui constituent la majorité des ménages ruraux du pays. La superficie moyenne par exploitation est de 4,30 ha.

L'espace agricole est dominé par la culture de l'arachide et du mil dans le bassin arachidier, l'élevage extensif en zone Sylvo-pastorale, les cultures vivrières et forêts au sud-est, les cultures de décrue le long de la vallée du fleuve Sénégal, la zone de culture du coton qui épouse les contours de la moitié Est du territoire gambien, la riziculture traditionnelle dans le bassin versant du fleuve Casamance, les cultures irriguées sous forme de périmètres qui sont localisées dans le Delta et la Moyenne vallée du fleuve Sénégal et dans la cuvette de l'Anambé au Sud et les cultures horticoles localisées principalement dans la zone des Niayes.

Cependant, malgré ces fortes potentialités, le secteur agricole sénégalais est affecté par de nombreuses contraintes liées essentiellement aux facteurs climatiques, édaphiques et économiques. A cela s'ajoute l'action anthropique qui amplifie les dérèglements climatiques. Le déboisement massif, les brûlis, l'activité minière ont eu pour résultat la dégradation des terres, l'érosion des sols, la réduction des capacités des terres à piéger le carbone, contribuant ainsi à l'augmentation des émissions de GES.

2.5. Energie

Le Sénégal dispose de peu de ressources énergétiques. Le bois et le charbon de bois représentent 57% du bilan énergétique du pays. Les ressources hydro-électriques potentielles sont estimées à 1400 MW

sur les fleuves Gambie et Sénégal. L'essentiel du pétrole consommé est importé. Les produits pétroliers pèsent lourdement sur la balance commerciale du pays ; en 2000, leur facture s'élevait à 248 milliards de FCFA soit 22,5% des importations. Le secteur énergétique est soumis ces dernières décennies à une crise aigüe, marquée par des pénuries récurrentes dues aux difficultés d'approvisionnement en produits pétroliers, liée à la flambée des prix des produits pétroliers (de 13 dollars en 1998, le cours du baril à atteint 147 dollars en Juillet 2008) avec ses effets pervers sur la compétitivité des entreprises et sur le prix des denrées de première nécessité.

L'État a déjà initié plusieurs actions dans le cadre de la réforme du secteur de l'énergie qui visent, entre autres, la libéralisation du secteur, la mise en place d'une agence d'électrification rurale (ASER) et le développement des énergies renouvelables entre autres.

Toutefois, l'accès aux services énergétiques demeure encore un problème malgré, la progression du taux d'électrification notamment celui de l'électrification rurale qui est passé de 6 % en 2000 à 12,5% en 2004. Le secteur énergétique Sénégalais connaît de nombreuses contraintes parmi lesquelles : la prépondérance du bois et du charbon de bois dans la consommation énergétique domestique qui se traduit par une forte pression sur les ressources ligneuses ; les faibles performances de la société nationale d'électricité ; la faible diversification des sources d'énergie et le niveau encore faible de l'utilisation des énergies renouvelables ; l'arrêt de la subvention sur le butane en 2008.

3. PRESENTATION DE LA ZONE D'ETUDE

Cette présente étude couvre les régions de Matam (départements de Matam et de Kanel) et de Tambacounda (départements de Bakel et de Goudiry). Ces régions sont les sites d'intervention du projet USAID.

3.1. La Région de Matam

Elle est située entre 14°20 et 16°10 de latitude Nord, 12°40 et 14°60 de longitude ouest. Elle est limitée au Nord par la République Islamique de Mauritanie et la région de Saint-Louis, au sud et au sud-est par la région de Tambacounda, au sud-ouest par la région de Kaolack, à l'est par la République Islamique de Mauritanie et à l'ouest par la région de Louga. Le fleuve Sénégal borde la région sur toute sa partie orientale et septentrionale, sur une longueur d'environ 200 Km.

La région couvre une superficie de 29.616 Km², soit environ 1/7 du territoire national. Ce qui fait d'elle la seconde région la plus étendue du pays après celle de Tambacounda. Elle comprend trois zone agro écologiques distinctes : le Walo ou la Vallée, zone située le long du fleuve où se pratique la culture irriguée et la culture de décrue; le Diéri, zone de culture sous pluie et le Ferlo ou savane arborée où le pastoralisme s'érige en mode de vie.

La répartition spatiale de la population donne au département de Matam la plus grande part avec 267 704 individus, suivis du département de Kanel avec 202 948 individus et de Ranérou Ferlo qui compte 54 289 individus.

La région est comprise entre les isohyètes 300 mm et 500 mm, avec des précipitations pouvant atteindre parfois 600 mm d'eau dans la partie sud. Les quantités d'eau et le nombre de jours de pluies annuelles sont croissants du Nord au Sud. Les départements les plus arrosés sont Kanel et Ranérou Ferlo. La

pluviométrie se caractérise par une forte variabilité interannuelle (figure 3). Les premières pluies sont en général enregistrées en fin mai ou début juin et les dernières sont recueillies entre fin septembre et mi-octobre.

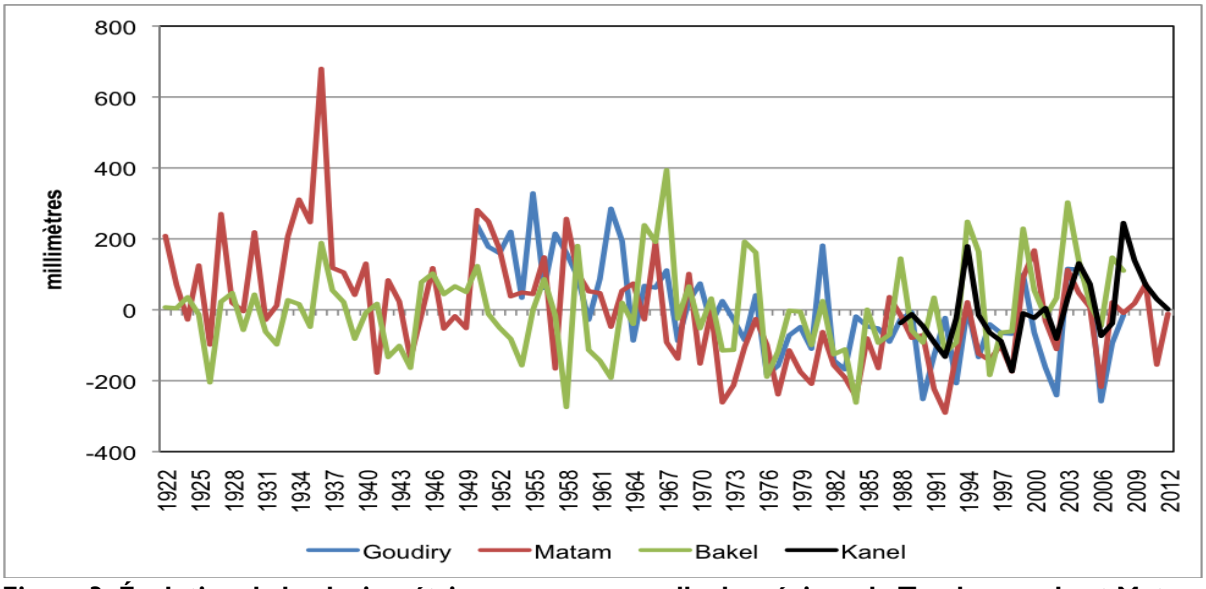


Figure 3: Évolution de la pluviométrie moyenne annuelle des régions de Tambacounda et Matam de 1922 à 2012

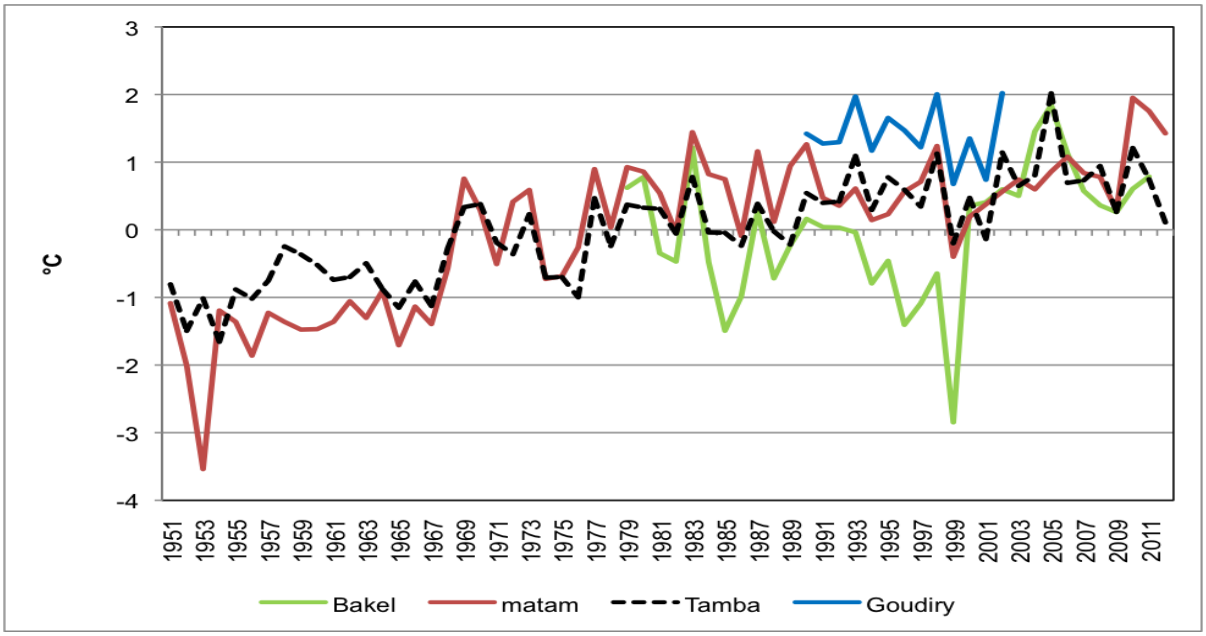


Figure 4: Evolution des températures moyennes dans la zone d'étude (1951 à 2012)

Les vents sont de différents types :

L'alizé continental, appelé Harmattan : vent de direction nord à sud-est, avec de l'air chaud et sec soufflant pendant la période chaude. Des vents de sables sont observés pendant les mois de mars à juin avec une vitesse atteignant des pointes de 28 mètres/seconde (100 Km/heure) accompagnée de poussières très denses et de direction nord-est à sud-est.

La mousson : vent chaud et humide soufflant pendant la période des pluies.

Le potentiel hydraulique de la région reste important et est constitué des eaux de surface et des eaux souterraines. Les eaux de surface sont constituées par le fleuve Sénégal (qui longe la région sur environ 200 km à l'est et au nord) et ses principaux défluents que sont le Diamel et le Diolol. A cela il faut ajouter de nombreux marigots et mares temporaires et permanents disséminés dans la région. Les eaux souterraines sont contenues dans: i) les nappes peu profondes ou phréatiques dont la profondeur varie entre 25 et 100 mètres ; ii) les nappes du Maastrichtien dont la profondeur peut atteindre parfois 300 mètres. Le niveau d'exploitation des eaux souterraines est faible à cause surtout de la profondeur des nappes engendrant des coûts d'extraction de l'eau très élevée.

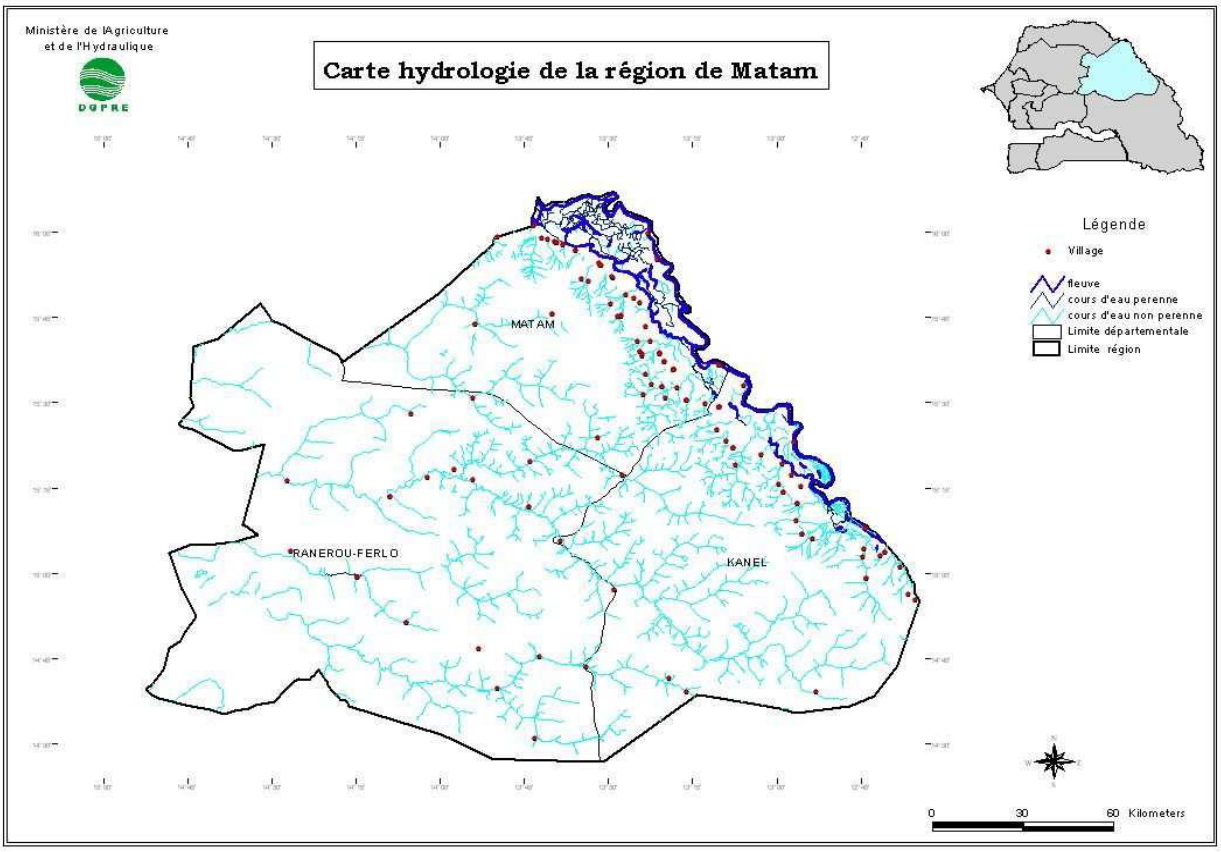


Figure 5: Réseau hydrographique de la région de Matam

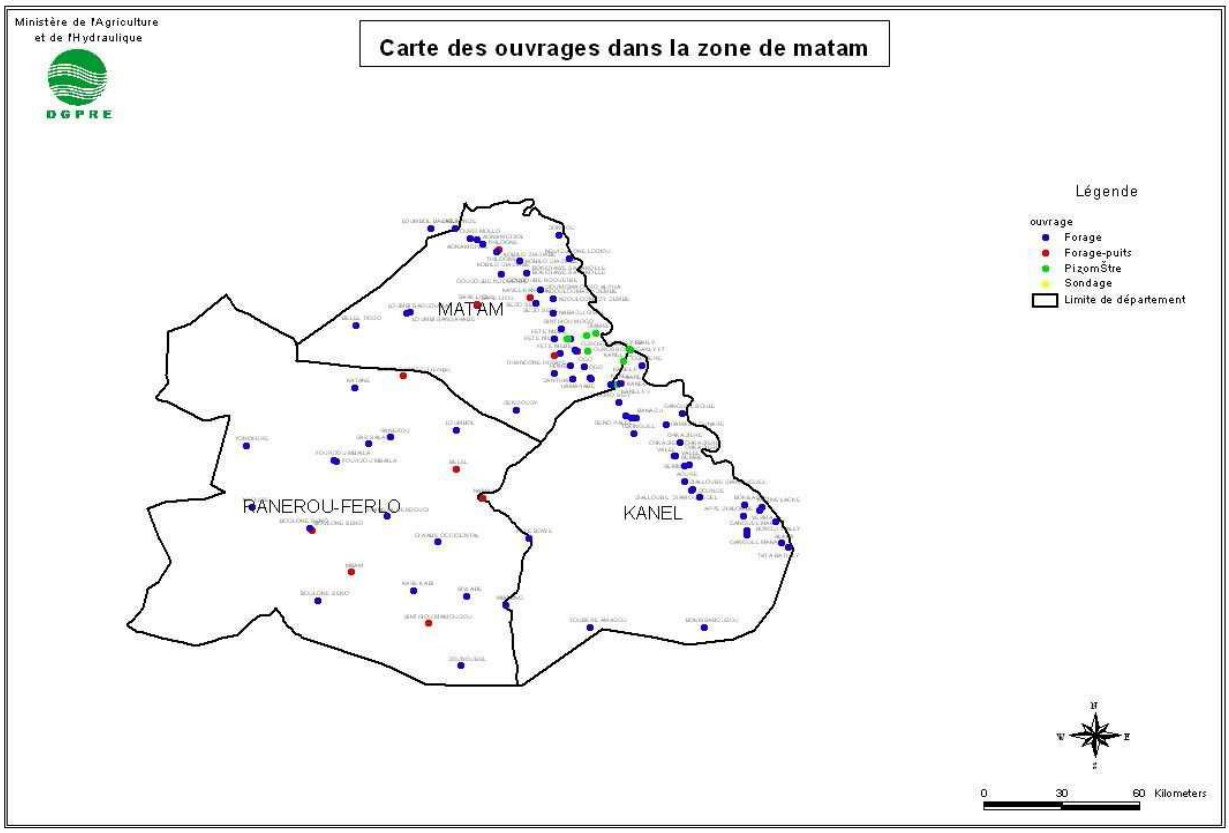


Figure 6: Cartographie des ouvrages hydrauliques réalisés dans la région de Matam

L'agriculture constitue la première activité économique de la région. En effet, elle occupe plus de 80% de la population régionale. On note une diversification des systèmes de culture avec l'introduction des cultures de sésame et de blé dans la zone. L'exploitation du sésame peut être bénéfique, car en plus des graines, on compte plusieurs marchés dont celui de l'huile, du tourtereau et des résidus de récolte exploitables par le cultivateur. On note également des cultures de contre saison avec le riz, la patate douce, et l'arachide. Les cultures de décrue y sont également réalisées.

L'économie de la région repose en grande partie sur l'élevage et ses produits dérivés du fait que la région a une vocation pastorale. L'importance du cheptel dans la région se ressent à travers son nombre et sa diversité. En effet, on trouve plusieurs espèces excepté le porc dont l'absence pourrait s'expliquer par sa forte connotation chrétienne sachant que la zone est à dominance musulmane. La région de Matam a fait un bon significatif avec 685 vaches inséminées au titre de la campagne 2009.

3.2. LA REGION DE TAMBACOUNDA

La région de Tambacounda est située entre 12°20 et 15°10 de latitude Nord et 11°20 et 14°50 de longitude Ouest. Elle est limitée au nord par la région de Louga, de Saint-Louis et la république de Mauritanie, au sud par la république du Guinée Conakry, à l'est par la république du Mali et de la Mauritanie, à l'ouest par les régions de Kolda, de Kaolack et de la république de Gambie. C'est la région administrative la plus vaste du Sénégal avec une superficie de 59602 km², soit 30% du territoire national. Sur le plan administratif, la région compte 3 départements, 13 arrondissements, 35 Communautés Rurales, 3 Communes et 1.465 villages.

La population régionale est estimée à 518.040 habitants en 2010. Le département de Bakel compte 140836 individus contre 91709 à Goudiry. La densité est très faible avec 8,3 habitants/km² et très inégalement répartie.

Cependant, sur le plan économique, la contribution de l'économie régionale au PIB national représente moins de 3%, malgré la présence d'importantes ressources et potentialités. L'économie régionale repose essentiellement sur le secteur primaire (77% du PIB). La contribution des sous-secteurs est la suivante : Agriculture (39,2%), Elevage (32,0%), Foresterie (6,2%).

Le climat de type soudano-sahélien et soudano guinéen, confère à la région des écosystèmes diversifiés, un environnement écologique généralement favorable au développement de l'agriculture et de l'élevage.

La région se situe entre les isohyètes 500 et 1500 mm et fait ainsi partie des zones les plus arrosées du pays. Par ailleurs, la région possède un important réseau hydrographique, constitué par le fleuve Sénégal, la Falémé et le fleuve Gambie, mais aussi la disponibilité d'une importante quantité d'eau souterraine dans le bassin sédimentaire. Le potentiel en eau est estimé à plus de 2.500 millions de m³, exploité seulement à moins de 1 million de m³/an.

Les ressources et potentialités agricoles sont très vastes : 2.092.000 ha de terres aptes à l'agriculture pluviale, d'importantes ressources en eau de surface et en eau souterraine disponible, 150.000 ha de terres irrigables. Sur le potentiel de terres irrigables (150 000 ha), seules 3000 ha sont exploitées (principalement pour la culture du riz dans le Walo). Il faut cependant signaler qu'il est prévu un programme de réalisation de barrages sur la Falémé et le fleuve Gambie.

Les productions vivrières sont passées de 94.502 T en 1995 à 110.659 T en 1999 et la production arachidière de 49.410 T en 1995 à 84.588 T en 1999. Par contre, la production cotonnière qui était de 5.000 T en 1999, a connu une chute vertigineuse de l'ordre de 80%.

La région compte un cheptel important et diversifié (493.800 bovins et 1.278.400 ovins caprins) et constitue une grande productrice de bétail sur pied (33 500 bovins et 177 500 ovins/caprins).

Les potentialités de la foresterie reposent sur d'importantes formations très diversifiées couvrant 5 406 300 ha, comprenant: 20.000 ha de forêts galeries, 1.496.600 ha de savanes boisées, 5.400 ha de steppes arborées, 3.684.500 ha de savanes arborées et 200.000 ha de savanes arbustives. Le domaine forestier est constitué de 17 forêts classées dont 4 dans le département de Bakel, 11 à Tambacounda et 2 à Kédougou, d'un parc national (le Niokolo Koba) et d'une Zone d'Intérêt Cynégétique (ZIC de la Falémé). L'ensemble de ces massifs couvre une superficie de 689844 ha soit 45% de la superficie régionale.

Concernant l'élevage, la région de Tambacounda constitue, à bien des égards, une zone privilégiée pour le développement des activités pastorales. On pratique dans la région 03 (trois) systèmes d'élevage à savoir : le semi intensif, l'extensif et le mixte. La région compte un cheptel important et diversifié. Les principales races de ruminants domestiques se répartissent en fonction des zones écologiques. Aujourd'hui, c'est un secteur de plus en plus confronter à des problèmes de gestion des ressources en eau et de pâturage à cause de l'accroissement des effectifs dû à une forte transhumance en provenance du nord et du centre du Sénégal et des pays limitrophes. Le secteur occupe une place importante dans

l'économie régionale en contribuant à hauteur de 32% dans la part du secteur primaire à la formation du PIB régional. Les ovins et les caprins représentent 72 % de l'effectif total du cheptel alors que les bovins font 25 %. Cependant c'est un secteur très vulnérable à cause de l'insuffisance du maillage des points d'eau pour l'abreuvement du bétail, la destruction des pâturages naturels par les feux de brousse, le manque d'organisation de la commercialisation et le caractère extensif de l'élevage qui fait qu'on a des performances en deçà des potentialités zootechniques du cheptel (productivité faible). A cela s'ajoute un manque de valorisation des produits dus à l'absence d'équipement de collecte, de conservation et de traitement de lait.

D'autres facteurs en amont expliquent cette situation à savoir : insuffisance des services vétérinaires, difficultés d'accès aux produits usinés, etc.

On note également des contraintes majeures qui concernent la commercialisation des produits animaux qui sont liées aux difficultés de transport, de conditionnement et de distribution, pour la consommation intérieure comme pour l'exportation.

4. ÉTAT DE LA RECHERCHE ET DE LA VULGARISATION DANS LE DOMAINE DE L'AGRICULTURE ET DES CHANGEMENTS CLIMATIQUES

Au Sénégal, plusieurs travaux de recherches ont été menés sur les effets des changements climatiques sur les secteurs de l'agriculture. En fait en raison de la place prépondérante de l'agriculture dans la vie économique, les problématiques de l'alimentation hydrique des cultures et la sécheresse sont très tôt apparues comme les thèmes de travail privilégiés de la discipline vers les années 1970. Ces études ont été effectuées en collaboration avec la division de bioclimatologie de l'INRA (Institut national de la recherche agronomique), en France, et des équipes sous-régionales des services nationaux de recherche agricole et du CILSS (Comité permanent inter-Etats de lutte contre la sécheresse au Sahel) et le CIRAD (Centre de coopération internationale en recherche agronomique pour le développement) dans le cadre de projets coopératifs tels que Espace. Cependant, on a constaté que la majorité des cas ont été faites à l'échelle nationale, alors que les initiatives visant l'adaptation en zone locale semblent être en nombre très limité.

4.1. Amélioration de la gestion des parcours

Le système d'élevage extensif pratiqué au Sénégal repose sur l'utilisation des parcours naturels et sur la transhumance saisonnière du cheptel. L'ampleur des mouvements varie selon les zones et les années en fonction des pluies, de l'état des parcours et des disponibilités en eau pour l'abreuvement du cheptel. La sous-alimentation du cheptel est fréquente, surtout en année sèche. Elle s'accompagne d'un état sanitaire généralement déficient, si bien que les performances zootechniques sont dans l'ensemble médiocres et nettement inférieures aux potentialités biologiques tant des parcours que du cheptel existant.

Partant de la connaissance de la production primaire des parcours au cours d'une année, le CSE élabore des conseils, d'une part, au profit des services de l'élevage et des eaux et forêts, en matière de gestion des ressources naturelles, et d'autre part, pour les pasteurs en matière de constitution et de conservation des réserves fourragères. Le suivi des parcours, permet d'évaluer à la fois la quantité (production primaire) et la qualité (composition floristique) du fourrage disponible dans les différentes zones écologiques du pays (figure 7), (http://www.cse.sn).

Les variations relatives de la quantité de biomasse produite d'une année à l'autre (figure 7), qui traduisent entre autres la résilience des écosystèmes, sont beaucoup plus sensibles dans la partie nord du pays. Le gradient pluviométrique Nord/Sud et la répartition spatio-temporelle des pluies constituent les principaux facteurs climatiques qui régissent la production des parcours naturels.

Le suivi de la production de biomasse effectué de 2007 à 2012 montre une variabilité dans la production primaire des parcours naturels. De manière générale, la zone sylvo-pastorale (pluviométrie < 400 mm/an) produit une quantité de biomasse relativement faible avec une bonne régression des légumineuses dans la composition floristique des parcours naturels. Les régions sud et sud-est (Tambacounda et Kolda) sont les plus productives de biomasse avec des valeurs moyennes allant de 4000 à plus de 7000 kg ms/ha. Le maximum de production y dépasse généralement 7000 kg ms/ha. Mais, cette zone est d'une part fortement affectée par les feux de brousse et d'autre part la qualité du fourrage y est plus grossière que dans la partie Nord à cause de la forte présence d'Andropogonées qui se lignifient très vite perdant ainsi progressivement leur valeur nutritive.

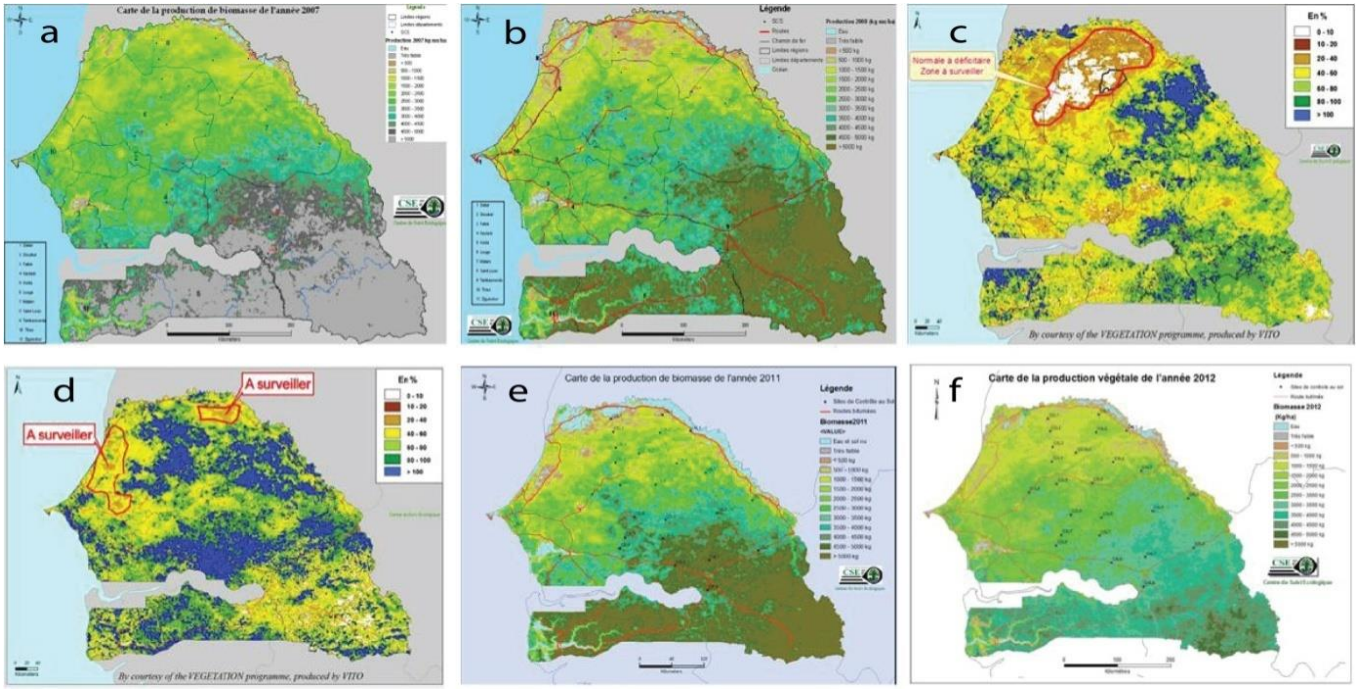


Figure 7: Cartes des biomasses végétales au Sénégal de 2007 à 2012 (a: 2007; b: 2008; c: 2009; d: 2010; e: 2011; f: 2012)

L'ISRA et le CIRAD Forêt ont également mené des études sur l'amélioration de la gestion des parcours forestiers naturels dans la région de Tambacounda (Nétéboulou) dans le cadre de la mise en œuvre du projet PROGEDE. Une étude menée par Mbaye *et al* (2000) a permis de mettre en place des parcelles de démonstration agro-forestières avec des espèces exotiques de légumineuses ligneuses inoculées à croissance rapide (*Leucaena leucocephala*, *Gliricidia sepium*, *Albizzia lebbeck*). Les arbres (*Leucaena leucocephala, Albizzia lebbeck*) sont disposés en lignes, espacées de 4 m avec un écartement de 1,5 m. Ce dispositif permet de mettre en place des cultures entre les ligneux et une exploitation de ces derniers comme fourrage par élagage ou broutage, ou pour une production de litière. Entre les lignes seront cultivés, selon les parcelles et les années, du coton, de l'arachide ou du fourrage. Ces jachères artificielles

proposées permettent d'améliorer également la fertilité du sol avec une meilleure utilisation du fumier produit dans les étables d'embouche ou de production laitière.

La gestion des parcours est apparue comme un enjeu majeur de la gouvernance environnementale locale, à travers notamment la délimitation des parcours de bétail, la réhabilitation des mares et la gestion préventive des conflits entre agriculteurs et éleveurs (CSE, 2009). Cependant, peu de conseils ruraux procèdent à la délimitation des couloirs de bétail. Cela s'explique pour la plupart aux manques de moyens pour baliser les parcours. La loi prévoit que ces couloirs peuvent s'étendre sur 50 à 100 mètres et que les agriculteurs doivent aménager des haies de protection lorsque leurs champs se trouvent sur le tracé. Cependant l'application de ces textes n'est pas facile. A Dagana dans la région de Matam, les travaux de Thiam (2009) ont montré que l'établissement de ces couloirs, à travers les périmètres de la Compagnie sucrière sénégalaise, apparaît problématique. Certains éleveurs ont du mal à déplacer leurs troupeaux dans ces espaces. Selon cet auteur, c'est au travers des processus d'adaptation dans l'organisation de la société pastorale que nous pourrons comprendre et apprécier la résilience ou la vulnérabilité de cette société.

Au Ferlo, le Projet d'Appui à l'Elevage (PAPEL) a organisé depuis les années 1990, la gestion des ressources naturelles à l'échelle des unités pastorales (UP). Les Unités pastorales (UP), promues par le PAPEL dans une large partie du Ferlo, consacrent cette territorialisation par le forage de puits. Sur un rayon de 20 km autour de ceux-ci, les UP constituent le cadre de gestion des ressources pastorales (parcours et pâturages, points d'eau…) par les éleveurs.

La conservation des ressources fourragères qui permet de stabiliser leur valeur nutritive, est également un élément important dans la gestion de la biomasse disponible. Dans les conditions d'élevage traditionnel en saison sèche, la conservation peut se faire par le séchage à l'ombre, qui ne détériore pas la qualité du fourrage frais pour les ligneux.

L'exploitation de ces ressources, constituées de parcours et de résidus de cultures, en zone subsaharienne, n'est permise que par la mobilité des troupeaux qui est l'élément majeur de flexibilité de ces systèmes. Cette forte dépendance entre présence des troupeaux et ressources végétales distribuées sur un territoire constitue une des clefs de la productivité animale. Ceci suppose d'intégrer les connaissances acquises, ou à acquérir, dans des approches spatio-temporelles des interactions entre troupeaux, ressources et pratiques d'élevage. En effet, une démarche spatialisée permettrait de mieux prendre en compte l'influence des circuits des troupeaux sur les performances individuelles. De plus, cette approche est nécessaire pour évaluer simultanément les composantes de la durabilité de ces élevages agropastoraux sur parcours. Une approche systémique qui englobe les troupeaux, les parcours, les pratiques et les bilans de matières (Ickowicz and Mbaye 2001, Manlay *et al.* 2004a, Manlay *et al.,* 2004b, Masse *et al,.* 2004) permet d'une part d'appréhender la richesse des interactions entre les éléments du système agraire, sans toutefois expliquer les relations dynamiques entre ressources et performances.

La gestion des ressources naturelles en contexte incertain (climatique, foncier etc). Le caractère foncier s'explique par le fait que les éleveurs n'ont pas souvent accès à la terre à cause de leur mode de vie nomade. En fait de façon culturelle au Sénégal, la terre appartient aux populations qui la mettent en valeur (aux agriculteurs), bien que ces derniers n'aient pas de papier légal, car l'État étant garant du patrimoine foncier. Ce contexte de précarité conduit les pasteurs à arbitrer entre les risques : minimiser

les risques alimentaires en quittant les zones les plus arides en saison sèche, utiliser la proximité des marchés au cours des transhumances, atteindre et utiliser les meilleurs pâturages. Ces actions peuvent les conduire, souvent en situation de marginalité sociale et/ou légale, à adopter parfois des comportements à risques, tout en minimisant les risques de conflits graves. En ce sens évidemment, la tentative de réguler localement les ressources naturelles, tout en tenant compte de la nécessité de la mobilité, est particulièrement intéressante.

L'objectif de ces techniques est de mettre à la disposition du cheptel un fourrage ligneux de qualité en quantité suffisante, pendant la période de déficit en fourrage herbacé, et de réhabiliter les pâturages naturels en introduisant des espèces ligneuses fourragères. Les recherches menées par le CNRF (Centre National de Recherche en Foresterie) et le LNERV (Laboratoire national de l'élevage et des recherches vétérinaires) ont permis de mettre au point des techniques de régénération assistée et d'enrichissement des parcs avec des ligneux fourragers connus (*Celtis integrifolia, Pterocarpuserinaceus, Pterocarpus lucens)* et d'identifier les fourragers ligneux disponibles sur les parcours naturels. Grâce à ces études, il a été possible de déterminer les espèces consommées et de hiérarchiser les choix, mais aussi de caractériser les relations allométriques entre la productivité fourragère et certaines variables dendrométriques de plusieurs espèces ligneuses et de mettre au point des modes de gestion pour garantir l'utilisation durable de certaines espèces ligneuses (Fall, 1993 ; Fall *et al.,* 2000 ; Fall et Samba, 2001).

4.2. Promotion de l'intégration de l'élevage dans les systèmes de culture

Les avantages de l'intégration de l'élevage dans les systèmes agricoles et en particulier, les conséquences à long terme de transférer les nutriments du parcours en terres cultivées sont toujours activement débattus (Ridder et van Keulen, 1990; Turner, 1995; Sumberg, 2003). Cette intégration peut avoir des effets positifs suivant trois niveaux : i) permet de résoudre la fertilisation des terres cultivées et la disponibilité d'aliments de bétail ; ii) permet l'utilisation du bétail pour les travaux de champs ; iv) et facilite la disponibilité de fonds via l'embouche bovine et la vente de lait qui permet d'acheter des intrants et vice versa.

Les améliorations de l'élevage de ces systèmes intégrés comprennent le passage à des pâturages intensifs grâce à des enclos de nuit, les plantations fourragères / la production de foin, et dans les zones les plus humides, la stabulation (l'affouragement en vert, le zéro pâturage). Les suivis réalisés en Haute Casamance montrent que les troupeaux, en consommant les ressources du terroir puis en les restituant de façon semi pilotée sous forme de fèces, peuvent maintenir la fertilité de plus de 30 % du terroir sans autres intrants (Ickowicz *et al.,* 1998 ; Manlay *et al.,* 2004a, 2004b).

Les déplacements des troupeaux jouent aussi un rôle important dans la circulation de la matière organique sur les terroirs et par conséquent dans le maintien de la fertilité des sols de plus de 30 % du terroir sans autres intrants (Manlay et al., 2004a, 2004b). Ces résultats montent qu'une meilleure intégration de l'agriculture et de l'élevage permet ainsi de lutter contre la baisse de la fertilité des terres agricoles. Ces systèmes sont bien adaptés dans les zones humides du Sénégal comme c'est le cas dans la zone de Tambacounda (Bakel et Goudiry).

Cependant l'intégration des systèmes agriculture/élevage nécessite des préalables pour une optimisation du système. Ce dernier doit être plus productif et plus durable, à travers le concept d'intensification écologique (Chaumet et al., 2009). Ces préalables nécessitent la mutation progressive des systèmes

traditionnels d'élevage des ruminans vers systèmes semi-intensifs, ou intensif privé. Dans ce cas le bétail devra se confiner graduellement dans une stabulation plus ou moins permanente, avec instauration de différents types d'affouragement.

Parmis ces préalables il faudra améliorer la disponibilité des fourrages, en intégrant les cultures fourragères dans les systèmes de production pour aller vers des systèmes intégrés. Dans ces différents systèmes, l'approvisionnement fourrager pourrait se faire essentiellement à partir des haies anti-érosives de différents espèces préconisées par la recherché en privilégiant une démarche participative (Pennisetum purpureum, arbustes fourragers comme le Leucaena leucocephala, le Calliandra calothyrsus et Acanthus pubescens). Il faudra également améliorer la valorisation des résidus de culture: fanes d'arachide et de haricot, feuilles et lianes de patate douce, feuilles de colocase et de taro, feuilles et troncs de bananier (Branckaert, 1990).

Les pratiques d'intégration agriculture/élevage devraient permettent d'augmenter la productivité et d'améliorer la durabilité des systèmes. Nous proposons d'analyser la contribution de ces pratiques aux processus d'intensification écologique et d'apporter un éclairage sur les conditions techniques, économiques et sociaux nécessaires à leur développement. Evaluer le niveau d'intensification écologique des exploitations nécessite donc de coupler l'analyse d'indicateurs de productivité et de durabilité.

Des expérimentations ont été réalisées sur la collecte et la conservation des fourrages entre 1990 à 1994 dans la zone sylvopastorale à Dahra et dans la région de Kolda par l'ISRA. L'objectif visé était d'identifier les principales stratégies utilisées par les paysans pour minimiser les problèmes de disponibilités alimentaires du fourrage en saison sèche. Des faucheuses à traction bovine ont été adaptées à la traction asine, puis diffusées dans le cadre des activités du programme national de vulgarisation agricole (PNVA). Des essais de fanage de fourrages naturels, en station et au champ, ont permis de préciser l'évolution de la perte en eau selon le temps et les facteurs environnementaux (Diop et al., 1992). Des techniques de conditionnement des fourrages adaptées aux conditions socio-économiques de la zone ont été testées. En zone subhumide, dans la région de Kolda, les contraintes de la fenaison ont été identifiées et un programme sur les réserves fourragères a été proposé. Des agropasteurs ont été formés en 1992 dans le cadre des activités du projet forestier de Dabo (Diop, 1991).

Pour améliorer la situation nutritionnelle du cheptel, des techniques de complémentation, d'amélioration et de gestion des potentiels fourragers des zones de pâturages, ont été mises au point par la recherche. Ces travaux ont permis de mieux apprécier les possibilités de valorisation des fourrages naturels par les ruminants domestiques. Plusieurs ressources alimentaires ont été explorées : les pâturages naturels de différentes régions du Sénégal, les résidus de récolte et sous-produits agroindustriels, les céréales locales, les ligneux fourragers, les fourrages cultivés, les ressources minérales et les farines animales. Les résultats obtenus permettent de raisonner le système d'alimentation des ruminants domestiques en fonction de l'espèce animale, de la saison et de la production.

L'introduction des ligneux dans le régime des ruminants est limitée par les risques d'intoxication. Des taux d'incorporation comprise entre 20 et 50 % sont en général recommandés. Ce taux permet de réduire les mortalités et obtenir des croissances modérées dans le cas de certaines espèces ligneuses. Les résultats obtenus permettent de proposer une sélection d'espèces ligneuses fourragères pour l'alimentation du bétail : *Acacia, Adansonia digitata, Leucaena leucocephala, Calotropis procera, Pterocarpus*

erinaceu. Les espèces comme *Panicum maximum* et *Pennisetum purpureum* permettent, sur des sols argilo-limoneux non salés, d'atteindre des biomasses moyennes de 18 à 22 t/ha de matière sèche. Le fourrage est de bonne qualité (0,7 UFL et 68 g de MAD par kilo de matière sèche).

Les sols limoneux à limono-argileux sont propices à la culture de plusieurs variétés de niébé (*Vigna unguiculata*) et d'arachide, qui produisent une biomasse moyenne de 5 t/ha de matière sèche. Ce fourrage est de bonne qualité avec 0,5 UFL/kg de matière sèche et 57 à 93 g de MAD par kilo de matière sèche. Vingt-six espèces fourragères ont été testées et leurs itinéraires techniques sont bien connus.

L'utilisation du pois d'Angole (*Cajanus cajans*) comme plante fourragère dans l'agroforesterie a été préconisée par la recherche. Cette légumineuse, est un arbre prometteur mais peu connu dans la zone. Elle donne des pois comestibles, du fourrage, fixe l'azote et rend le phosphore disponible. Elle peut être souvent utilisée dans les jachères améliorées. Le semis peut se faire en lignes continues, en poquets ou à la volée. Dans le cas du semis en poquets environ 5 à 10 grains sont semés par poquet. Les feuilles de la plante peuvent être utilisées pour l'affouragement des animaux. Ces feuilles sont riches à la fois en protéines (21-25%/MS) et en fibres (30-35% de cellulose brute/MS)

L'insuffisance de fourrage de qualité acceptable est le problème clef de l'élevage au Sénégal. C'est pour ces raisons qu'une amélioration de la qualité et de la quantité de l'alimentation des bovins et ovins est recommandée pour la zone. Cette amélioration peut se faire à travers l'utilisation de la culture fourragère (fourrage de niébé et du pois d'Angole) et une exploitation des résidus de récolte (fanes de niébé et d'arachide) dans la supplémentation des animaux.

Pour une réussite de l'intégration de l'élevage et de l'agriculture, il existe également des études sur l'amélioration des régimes alimentaires du bétail qui ont été proposés

Les régimes alimentaires suivants ont été proposés

RAVAL 2 :

Formules : 47 % de coque d'arachide, 35 % de graines de coton, 16 % de son + mélasse + urée, 2 % minéraux (0,7/kg MS de UFL, 75/kg MS de MAD, 7g/ kg MS de calcium, 5g/kg MS de phosphore).

RAVAL 8

Formules : 32,5 % de coque d'arachide mélassée, 40% de céréales (maïs ou sorgho), 5% de tourteaux d'arachide, 20% de graine de coton, 2,5% de minéraux (composée de 0,7\kg MS de UFL, 86g\kg MS de MAD, 7,9g\kg MS de calcium et de 3,8g\ kg MS de phosphore)

Performance : Pour une consommation moyenne de 3kg MS\100 kg de poids vif et une production moyenne de 15 litres \jour de lait.

RAVAL 4

Formules : Formule de 25 % de coque d'arachide, 55% de graine de coton mélasse, 18% de son de blé mélassé et 2 % de minéraux et une composition de 88 % de MS, 0,7/kg MS d'UFL, 72g/kg MS MAD, 6g/kg MS de calcium et 5g/kg MS de phosphore

Performance : Consommation moyenne de 3 à 3,5kg MS/100kg de poids vif et une production de 15 litres/jours lait.

EMBOUCHE BOVINE SEMI INTENSSIVE : ration 1

Formule : Aliment de base d'un pâturage naturel de saison sèche et une concentration de 75% de son de riz, 25% de gain de coton.

Performance : Lâchage des animaux sur pâturage naturel toute la journée et distribution d'1 kg du concentré par animal par jour. Son gain de poids est de 230g\animal.

NB : Pour un animal d'âge moyen de 2 ans et un poids moyen de 250 kg.

L'un des contraintes de la recherche développement au Sénégal est que le niveau de vulgarisation est très faible. Ces formules proposées, peuvent être vulgarisées qu'en élevage intensive ou semi intensive. Ce qui n'est pas une pratique majoritaire au Sénégal.

La vulgarisation de ces différentes technologies nécessite au préalable une sensibilisation et une réorganisation de l'élevage extensif vers un élevage semi intensive avec une intégration de l'agriculture/élevage. Il est également nécessaire d'aller vers une professionnalisation des acteurs.

4.3. Accès à de nouvelles variétés adaptées

De nombreux acquis de la recherche existent pour les différentes spéculations cultivées au Sénégal (sorgho, riz, maïs, mil, arachide, niébé etc.).

Des recherches ont été également faites sur le diagnostic hydrique et le zonage agroclimatique et ont permis de préciser les effets des facteurs climatiques sur le matériel végétal, le sol et les techniques culturales et d'implanter des variétés résistantes à la sécheresse (Diagne, 1992).

De nombreux auteurs ont effectué des recherches sur l'adaptation à la sècheresse et la création variétale des cultures (mil, maïs, arachide, niébé) en zone tropicale (Annerose, 1990, 1991 ; Marone, 1996 ; Clavel *et al.,* 2004 ; Sarr *et al.,* 1999 ; 2001 ; Diouf *et al.,* 2001 ; Diouf, 2000). Ces études ont abouti à l'acquisition de connaissances pour la conduite de programmes de création variétale en matière de résistance ou de tolérance à la sécheresse. Ces programmes ont permis de sélectionner des variétés d'arachide à cycle court de 80 jours (Clavel, 1999). L'une d'entre elles, la GC8-35, est actuellement cultivée dans le nord du bassin arachidier et, sous irrigation dans la vallée du fleuve Sénégal. Ces études ont aussi permis de mieux comprendre les réponses au déficit hydrique de la variété d'arachide Fleur-11, qui se caractérise par sa haute productivité et la grande stabilité de ses rendements par rapport à la 55-437 (Clavel et Ndoye, 1997). L'ISRA a également entrepris un programme d'hybridation avec la GH119-20, qui a débouché sur la création de deux nouveaux cultivars, 73-27 et 73-28, (Dimanche *et al.,* 1997a) initialement destinées à la région de Tambacounda, mais qui peuvent être cultivées dans les zones de Nioro, de Fatick et de Kaolack (Ndoye, 2001b). Les autres variétés préconisées par la carte variétale dans la région de Tambacounda sont la 57-313 et la 73-33 (variétés érigées, à cycle long). Pour la région de Matam, correspondant à la zone Nord, il n'y a pas eu de recommandations spécifiques pour cette zone au moment de l'élaboration de la carte variétale de l'arachide. Mais certaines variétés nouvellement étudiées peuvent être vulgarisées dans la zone d'étude (voir tableau 1).

Les variétés les plus vulgarisées et utilisées par les producteurs sont la 73-33 et la 55-437 dans les zones centre (Bassin arachidier) et dans la région de Tamba. La 57-313 est également vulgarisée dans la zone de Tambacounda. La variété 73-30 est la moins vulgarisé, cependant c'est la plus résistante à la variabilité

climatique. Elle s'adapte dans les zones à pluviométrie irrégulière et à pluie tardive comme dans la zone de Matam.

Au Sénégal, seulement 15% environ des semences de cultures sèches (céréales, légumineuses) sont achetées et moins de 10% sont des semences certifiées, le reste provenant des stocks de l'année antérieure (Document WAAPP du Sénégal).

Tableau 1: Variétés d'arachide pouvant être recommandées dans la zone d'étude

Variétés	Caractéristiques	Zones de diffusion
57-422	Cycle de 105 à 110 jours. Résistance moyenne à la sécheresse et sensible aux maladies de Cercosporiose, peu sensible au jaunissement de la graine, tolérante au Clamp. Densité optimum au semis est de 100.000 pieds/ha	Goudiry, Bakel
73 33	Cycle de 105 à 110 jours. Résistante à la sécheresse et aux maladies. Excellente variété d'une plasticité remarquable lui conférant une bonne faculté d'adaptation. Cependant, son taux de maturité complète est relativement bas dans des conditions climatiques mauvaises.	Goudiry, Bakel
55-33	Extra précoce, adaptée dans les régions à saison des pluies très courtes. Rendement 3 à 4 t/ha, possède des graines relativement grosses. Bon rendement aux conditions pluviométriques normales	Matam, Kanel
73-30	Densité optimale au semis est 160000 pieds/ha et résistante à la sécheresse (95 j). Lignée de complément pour les zones à hivernage très irrégulier, sa dormance doit permettre de subir des pluies tardives.	Matam, Kanel
SRV1-19	Cycle court 90 jours. Variété est précoce à graine relativement grosse bien adaptée dans les régions sèches. Bon potentiel de rendement quel que soit les conditions pluviométriques	Matam, Kanel
73-9-11	Cycle court (80 J). Variété extra précoce, très bien adaptée dans les régions à saison des pluies très courtes. Rendement en gousses de 3 à 4 t/ha.	Matam, Kanel, Bakel, Tamba
PC79-79	Cycle long 120 j. Résistante à la Cercosporiose	Goudiry, Bakel

La sélection récurrente sur trois populations locales de mil Souna (Diouf, 2000 ; Gupta, 1984) a abouti à la création de la variété synthétique Souna-3 qui est vulgarisée dans la zone Nord (pluviométrie inférieur à 600 mm). Cette variété se caractérise par une résistance au charbon, une tolérance au mildiou. Des travaux effectués par l'ICRISAT ont conduit à la création d'hybrides résistant au mildiou et au charbon. C'est le cas de la variété ICMH-8413 (81A x IBMI-8207), avec une production de grains de 31 à 52 % supérieure à celle de la variété Souna-3 (Ndoye et Gupta, 1987a, 1987b). C'est aussi le cas des variétés

IBV-8001 (85 jours), IBV-8004 (75 jours) et IBMV-8402 (75 à 80 jours), qui sont vulgarisées dans la zone nord et centre nord. De nouvelles obtentions plus productives que les variétés actuellement recommandées (13 à 22 % de plus-value de rendement) sont actuellement proposées pour des tests en milieu paysan. Il s'agit de ICTP-8203 et GB-8735, pour la zone nord, de ISMI-9301 et ISMI-9305, pour la zone centre nord.

Par ailleurs, les études faites par Diop *et al.,* (2005) sur la simulation du bilan hydrique du mil ont permis de montrer que les indices de rendement espéré (IRESP et IPESP) des variétés de mil photopériodiques sont significativement supérieurs à ceux des variétés non photopériodiques, notamment dans la moitié sud du Sénégal. Ainsi, la réintroduction des variétés photopériodiques au Sénégal permettrait d'améliorer l'alimentation hydrique du mil, dans les zones de Goudiry et Bakel. L'introduction de ces variétés photopériodiques, augmenterait le potentiel de rendement de grain ou de paille (gain de 174 kg/ha dans le centre-sud).

Tableau 2: Principales variétés de mil vulgarisées dans la zone d'étude

Variétés	Domaine de recommandation	Durée du cycle	Rendement moyen en milieu réel (t/ha)
Souna 3	Zone sud : Bakel et Goudiry	90	3,5
IBV-8001	Zone sud : Bakel et Goudiry	80	3,4
IBV-8004	Zone Nord : Kanel et Matam	75	2,6
IBMV-8402	Centre Nord	80	2,5

De nouvelles obtentions plus productives que les variétés actuellement recommandées (13 à 22 % de plus-value de rendement) sont actuellement proposées pour des tests en milieu paysan. Il s'agit de ICTP-8203 et GB-8735, pour la zone nord, de ISMI-9301 et ISMI-9305, pour la zone centre nord du Sénégal, et de SOSAT-C88 et ICMV-IS-88305, pour la zone centre sud du Sénégal.

Concernant le riz, les recherches effectuées ont permis de mettre au point différentes variétés bien adaptées aux conditions écologiques du Sénégal, avec des rendements moyens de 6 à 7 t/ha et des pointes pouvant atteindre 10 t/ha. Il s'agit de la Jaya, Sahel 102, Sahel 201 et Sahel 202. Les zones de Bakel et Matam (partie de la zone du fleuve Sénégal) font partie des principales zones de production du riz au Sénégal. Le riz pluvial est cultivé dans la zone de Casamance, de Fatick et Kaolack avec les variétés Nérica diffusées par la recherche.

Concernant le maïs, des variétés précoces à intermédiaires de 90 jours et à cycle court (80 jours) ont été sélectionnés par la recherche. Il s'agit des variétés (Across-Pool-16-DR, TZEW-Pop x 1368-STR-C1, AK-9331-DMR, EV DT97STR-C1, Acr-94-TZE-Comp-5-W, Synth- 9243, Suwan-1 et DMR-ESR-W, avec des rendements de 4 à 6 t/ha. Les nouvelles variétés sélectionnées sont toutes vulgarisées. Il y a aussi des variétés hybrides jaunes à cycle intermédiaire (9903-2, Oba-Super-2(RE).

Tableau 3: Variétés de maïs pouvant être vulgarisés dans la zone d'étude

Variété	Caractéristiques	Zones
Composite A	Cycle 90j. Rendement de 3t/ha. Bonne résistance à la verse et à certaines maladies.	Bakel, Goudity,
CP75	Cycle court 75j. Rendement 2 t/ha. Aliments de soudure utiles pour les masses paysannes.	Matam et Ranérou
QPM1	Cycle court 85 à 95 j. Très haute valeur nutritive, riche en lysine et en tryptophane. Rendement de 4 à 5 t/ha. Permet de compenser le déficit protéinique des populations sensibles.	Matam, Kanel Bakel, Goudity,
Early Thaï	Cycle de 75 à 80j. Rendement de 2 à 4t/ha. Très grande vitrosité du grain le destine à la consommation humaine sous forme de couscous et de semoule	Matam, Kanel
Population du Sénégal oriental	Variété est issue de l'écosystème local et a été améliorée par test S1. Elle a gardé sa rusticité et convient aux pratiques culturales traditionnelles. Rendement de 2 à 3t/ha.	Bakel, Goudiry
BDS III	Cycle court 85 à 90j. Couleur blanche (graine). Rendement potentiel de 4 à 5t/ha. Bonne résistance à la sécheresse.	Bakel, Goudity, Matam et Ranérou
HVB1	Variété hybride destinée à l'intensification. Résistante à la verse. Cycle de 90j. Rendement potentiel entre 6 à 7t/ha.	Bakel, Goudiry.

Le sorgho est une culture traditionnelle pratiquée en système pluvial dans la région de Tambacounda, mais aussi en système de décrue et en irriguée dans la zone de Matam. Pour la culture pluviale, il existe trois types de sorgho constitués essentiellement de variétés locales : la 50-59 (précoce), la 63-18 (intermédiaire) et la SH60 (tardive). Ces variétés sont peu productifs, photosensibles et valorisent mal les techniques d'intensification. Les variétés améliorées, ont presque toujours connu une diffusion relativement limitée en raison de leur manque d'adaptation aux conditions agroclimatiques, de leur très grande sensibilité aux moisissures et de la qualité de leur grain, peu appréciée des populations rurales. La variété F2-20, qui a un potentiel de rendement élevé de 5,3 t/ha, une qualité de grain appréciée et une tolérance aux moisissures, plus tardive (110 jours), est recommandée pour les zones à pluviométrie supérieure à 600 mm. Elle peut s'adapter dans la zone de Tambacounda. Des lignées et des hybrides précoces, adaptées à chacune des deux saisons de culture (hivernage et contre-saison froide) au niveau

des périmètres irrigués de la vallée du fleuve Sénégal, ont été sélectionnées par la recherche. Il s'agit des variétés CE 151-262 (90j) pour la culture d'hivernage et 75-14 pour la contre-saison froide, des hybrides (612A x 68-29 recommandée pour les deux saisons, CK 612A x 73-208 (rendement de 4,2 à 7,7 t/ha) pour l'hivernage, CK 612A x 75-14 et CK 612A x 68-29 pour la contre-saison froide). Cependant, il convient de préciser que ces hybrides n'ont pas fait l'objet d'une production spécifique au Sénégal (tableau suivant). Le plus grand problème actuel du sorgho, est l'effet alléllopathique qu'il induit sur les autres cultures.

La recherche sur l'amélioration variétale du sorgho devra trouver des solutions permettant soit de réduire les teneurs en composés phénoliques par voie génétique, soit d'éviter l'effet allélopathique (sans supprimer la production des composés responsables) en semant la culture suivante au milieu des interlignes du précédent sorgho (Sène, 1999).

Tableau 4: Variétés de sorgho vulgarisées au Sénégal

Variétés	Zones recommandées	Durée cycle (j)	Rendement moyen en station t/ha
CE-145-66	Centre–nord, Sine Saloum	100	5,4
CE-180-33	Centre nord	90	5,3
80-4	Nord Sénégal	67j résistante aux maladies foliaires et aux moisissures.	19 et 35 qu/ha suivant la pluviométrie (500 à 700 mm)
CE-196-7-2	Mbour	95	5
F2-20	Centre sud, Tamba, Casamance	110	5,3

Concernant le niébé, les deux facteurs limitant de la culture sont la sécheresse et le parasitisme (Sarr *et al*.., 2001). Ainsi le programme d'hybridation et de sélection qui a été initié, a accordé une grande priorité aux problèmes de résistance à la sécheresse en utilisant la précocité comme critère de sélection. Les travaux d'amélioration variétale ont permis de développer des variétés intéressantes comme la N58-57 et la N5 9-25. Certaines variétés américaines ont été utilisées dans des croisements avec des variétés locales pour leurs caractères de résistance à la sécheresse, à la chaleur, aux insectes et aux maladies (Hall, 1983 et 1984). Les sources de précocité des variétés : 78-37, VCS-14, TVIJ-1174 et KVU-69 ont été identifiées en vue d'améliorer les variétés locales : Mougne, Ndiambour, Bambey 21 et 58-57. En ce qui concerne la résistance aux insectes, trois principaux groupes d'insectes constituent des contraintes à la culture et au stockage du niébé au Sénégal. Il s'agit d'*Amsacta moloneyi*, des thrips et des bruches. La sélection visait à créer des variétés adaptées aux conditions semi-arides et résistantes aux maladies et au striga. Bambey 21 a été la première variété extra-précoce (60 jours) et à port érigé développée au Sénégal. Mouride est une variété résistante à la bruche, au striga, au chancre bactérien et à la virose (Cissé *et al.,* 1995). Elle est semi-érigée et arrive à maturité environ 65 jours après le semis. Mélakh est une variété à double usage, créée pour la production de graines sèches et de gousses ou haricots verts (Cissé *et al.,* 1997). Elle est résistante aux pucerons, à la virose due au chancre bactérien et partiellement aux thrips.

Les recherches sur la domestication et la valorisation des fruitiers forestiers ont donné des résultats qui permettent d'améliorer leur productivité et de raccourcir leur cycle de fructification. Pour ce qui est du raccourcissement des cycles de fructification, des résultats ont été obtenus récemment sur quelques espèces (tableau 5). D'autres études visant les mêmes objectifs sont en cours sur des espèces d'intérêt économique.

Tableau 5: Espèces forestières domestiquées

Nom espèce	Cycle naturel (ans)	Cycle raccourci (ans)	Zones
Andansonia digitata	20	5	Bassin arachidier
Balanites aegyptiaca	5	3	Zone Nord et Sud
Saba senegalensis	5	2	Zone Sud et est
Tamarindus indica	15	4	Zone Nord et Sud
Zizyphus mauritiana	4	1	Zone Nord et sud
Détarium senegalensis	20	6	Bassin arachidier

La diffusion des acquis reste un atout majeur pour l'adaptation aux changements climatiques. Les obstacles structurels à la diffusion des technologies sont nombreux : manque de spécialistes et d'infrastructures appropriés, maque de financement durable (on assiste souvent à de petits projets de 3 à 5 ans maximums), absence de systèmes de gestion de droit de propriété intellectuel, faible capacité de communication, faible niveau de soutien politique, et faible niveau d'éducation de base des producteurs).

Des actions prioritaires sont à prendre en compte visant à : i) créer les conditions permettant d'améliorer la qualité et d'assurer la pérennité des services nationaux de recherche agricole, de vulgarisation et d'appui conseil ; ii) dynamiser les organisations des producteurs et les opérateurs privés ; iii) appuyer la décentralisation en vue de dynamiser les cadres de concertation des organisation de producteurs et d'éleveurs au niveau local ; iv) et éviter les mécanismes top-down en favoriser la recherche action participative. Il faudra aussi que l'État assure un rôle de veille en ayant un contrôle sur les multitudes de programmes et d'ONG. Le manque de cadre organisationnel de ces structures dans certains cas ne contribue pas à optimiser leurs actions.

Récemment le Programme de productivité agricole, dans sa première phase, a diffusé plusieurs acquis dans des domaines variés de la recherche agricole (document de rapport WAAPP, 2012). Ces acquis concernent, entre autres, la mise au point de technologies de 4 nouvelles variétés de sorgho (Guinthe : 110 jrs, 2 à 3 t/ha ; Faourou : 105 jrs, 2,5 à 3 t/ha ; Darou : 105 jrs, 2,5 à 3 t/ha ; Nganda : 110 jrs, 2 à 3 t/ha) de haut rendement par rapport aux variétés locales.

Un autre acquis porte sur 3 nouvelles variétés de mil que sont (Thialack 2 : 95 jrs, 2,1 à 3 t/ha ; Gawane : 85 jrs, 2,5 à 3,2 t/ha ; Ismi 9507 : 85 jrs, 2,4 à 3 t/ha). Ces variétés ont un haut potentiel de rendement et répondent à certains critères de choix des producteurs (cycle précoce ou intermédiaire, épis longs) par rapport aux variétés traditionnelles cultivées comme le Thialack, la souna locale et/ou le sanio qui posaient des problèmes d'adaptation aux nouvelles conditions agro-écologiques des zones de culture.

4.4. Promotion de pratiques culturales adaptées

Les études faites sur la fertilisation montent que la courbe de réponse du mil à des doses de fumier, qu'une dose de 1 à 3 t/ha donne une plus-value de 20 à 35 % et même double le rendement par rapport au témoin sans fumier (Badiane, 1988). L'utilisation agricole des résidus de poisson fumé à la dose de 4

t/ha tous les deux ans permet également d'augmenter le rendement par rapport à la fumure minérale recommandée (Ndiaye, 1996).

La fumure organique (fumier de poisson à raison de 10 t/ha) permet également de limiter l'effet allélopathique du précédent sorgho, (Burgos-Leon *et al.,* 1980). Cet effet allélopathique du sorgho, qui réduit la germination et la croissance de l'arachide, est attribué à des composés phénoliques dont l'accumulation est fortement et positivement corrélée avec la croissance du sorgho (Burgos-Leon et al., 1980 ; Sène, 1999 ; Sène et al., 2000 ; Sène et al., 2001a ; Sène et al., 2001b).

Des recherches sur la réduction des pertes d'azote dans les rizières grâce notamment au placement profond de l'Urée ont été également menées dans les zones irriguées par l'ISRA et l'IFDC. C'est une technologie de fertilisation localisée permettant de réduire la quantité de fertilisants utilisée pour la culture. 1 à 3 grammes de super granulés d'urée ou de briquettes sont enfouis à une profondeur de 7 à 10 centimètres du sol, 7 jours après le repiquage du riz. Ces résultats permettent d'optimiser l'usage des engrais mais aussi de contribuer à la réduction des émissions d'hémioxyde d'azote dont le pouvoir réchauffant sont 310 fois supérieures à celui du dioxyde de carbone. La technologie UDP (Urea Deep Placement) est actuellement vulgarisée dans la vallée du fleuve du Sénégal sur le Riz et le maïs.

Parmi les technologies préconisées pour réduire la vulnérabilité aux changements climatiques, il y a les technologies agroforestières. Les études sur l'influence des espèces ligneuses des parcs arborés, comme *Cordyla pinnata, Acacia albida* et *Sclerocarya birrea*, sur les sols et les cultures montrent que les variables pédologiques et les rendements agricoles varient en fonction de l'espèce ligneuse considérée. L'influence de *Acacia albida* est bénéfique pour le sol et les cultures (Charreau, 1970 ; Jung, 1967) alors que le rendement en grains du mil est réduit à proximité du *Cordylia pinnata* (Samba, 1997). L'interception de l'eau de pluie dans ce parc représente 22% des précipitations brutes, ce qui réduit significativement l'alimentation en eau des cultures sous-jacentes (Samba *et al.,* 2001). Les études sur *Sterculia setigera* montrent que malgré son rôle économique, alimentaire et pastoral très important pour les populations rurales (Sène, 1994), cette espèce peut exercer un effet dépressif sur les cultures (Bakhoum *et al.,* 2001), surtout sur les céréales.

Parmi les technologies diffusées par la recherche, il ya :

- Les brise-vents qui visent principalement à protéger les sols et les végétaux des vents. L'introduction de brise-vent dans les périmètres irrigués villageois de la vallée du fleuve a permis d'augmenter de 23 % le rendement du riz (DRPF, 1993) et d'améliorer le revenu des paysans par la vente des perches de *E. camaldulensis*. Ces avantages expliquent pourquoi plus de 65 % des producteurs de la vallée ont adopté les brise-vent. Les espèces préconisées dans la région de Tambacounda sont les *Acacias (Holosericea occidentale, indica*) *Eucaluptus camaldulensis* et le *Prosopus juliflora* ;
- Les tests d'introduction d'espèces dans les cultures en couloirs ont donné des résultats intéressants avec le *Leucaena leucocephala* en association avec les cultures de mil, d'arachide et de maïs dans la zone d'étude.
- La régénération naturelle assistée (RNA) est actuellement vulgarisée par les ONG.

4.5. Amélioration de l'exploitation des ressources naturelles

4.5.1. Exploitation des ressources en eau

Le secteur des ressources en eau au Sénégal a fait l'objet d'une étude approfondie (Malou R., Dacosta H. *et al.*1999) qui le classe parmi les secteurs les plus sensibles aux mutations du climat et ceci, malgré le potentiel de ressources hydriques relativement important dont dispose le pays.

Le déficit chronique de la pluviométrie observé à partir des années 1970 a amené les autorités à privilégier l'irrigation pour augmenter et sécuriser la production agricole. L'utilisation agricole des ressources en eau s'est donc considérablement renforcée sous l'impulsion des pouvoirs publics de 1975 à la fin des années 1980, avec l'extension des interventions à toute la vallée du fleuve Sénégal, à la Casamance, au bassin de l'Anambé, ainsi qu'au fleuve Gambie. A cela s'ajoutent des initiatives privées, notamment dans le delta du fleuve Sénégal, encouragées par la réforme foncière de 1985, par laquelle l'Etat a transféré la gestion du domaine national aux conseils ruraux. Elles concernent la riziculture et viennent renforcer les aménagements privés existant dans la zone horticole des Niayes.

Les aménagements du fleuve, réalisés dans le cadre de l'OMVS, comprennent plusieurs ouvrages. Le barrage de Manantali, a pour fonction de stocker l'eau et de réguler l'écoulement par des lâchers contrôlés pour maintenir un débit nominal à Bakel de 300 m^3/s durant toute l'année. Les lâchers contrôlés au niveau de Manantali permettent de créer des crues artificielles afin de sauvegarder les cultures de décrue et de préserver les biotopes du Oualo dans le lit majeur. Les cultures irriguées, par contre, connaissent une certaine expansion avec les aménagements de la SAED et du PRODAM. Avec 195 ha actuellement en exploitation, un projet de nouveaux périmètres initiés par la SAED prévoit la mise en place de 448 ha supplémentaires. Les cultures irriguées ne sont rendues possibles que par la présence du fleuve qui, à l'aide de GMP (Groupes motopompes) permet l'approvisionnement en eau des périmètres. Toutefois, les prélèvements effectués n'ont pas d'incidence sur la quantité d'eau mais la surveillance de la qualité est nécessaire pour éviter les rejets de produits toxiques issus des pesticides et qui pourrait contribuer à une pollution des eaux du fleuve.

Le barrage anti sel à Diama, dans le delta du fleuve Sénégal, peut s'ouvrir en hivernage pour laisser passer le débit excédentaire et se fermer en étiage pour empêcher la langue salée de remonter dans le fleuve. Il permet ainsi d'irriguer les cultures de contre-saison, mais aussi d'approvisionner en eau douce les hommes et le bétail du delta et de la moyenne vallée. L'aménagement des périmètres irrigués avec une maîtrise totale de l'irrigation permet la double culture annuelle. L'eau du fleuve est surtout utilisée pour l'agriculture irriguée depuis la réalisation des aménagements. Les systèmes de culture pratiqués sont variés, du fait de la longueur de la vallée (600 km entre Bakel et l'embouchure) et surtout de la grande diversité des climats (pluviométrie de 200 à 1 000 mm et plus de 2 degrés de différence de latitude).

Cependant les rives du fleuve Sénégal surtout la zone allant du Delta jusqu'au-delà de Dagana (sur près de 200 km) est la plus affectée par le typha et d'autres plantes aquatiques comme. On estime que 95% des axes hydrauliques des grands aménagements du Delta sont colonisés par des bandes épaisses de typha. La prolifération du Typha nuit aussi à la biodiversité, parce que le Typha a tendance à constituer des peuplements denses homogènes et donc mono-spécifiques. La prolifération de ces végétaux aquatiques nuisibles est donc un des problèmes environnementaux les plus préoccupants dans cette zone, ceci non seulement du point de vue de l'ampleur du phénomène mais aussi de ses incidences écologiques et socio-économiques et de la difficulté de son éradication. Ce volet est en prendre en

compte en préconisant des méthodes de lutte intégrée comme la lutte mécanique qui peut-être combinée à la promotion de la valorisation économique de la végétation collectée : utilisation comme combustible (bio méthanisation ou pour faire du biocharbon), ou comme matériaux de construction, pour la fabrication de papier, etc.)

Cependant l'exploitation des ressources en eaux est très limitée au sein du territoire national, par rapport aux potentialités énormes existantes. Chaque année, au moins 15 milliards de mètres cubes d'eaux de pluies sont perdues vers la mer. Et comme l'agriculture a besoin d'eau, il est important d'avoir une bonne maitrise de l'eau pour booster la production agricole du pays. Le Sénégal a, d'ailleurs, mis en place, en 2000, un projet de création de bassins de rétention. Des ouvrages qui servent à collecter et à stocker des eaux de pluies qui se perdent dans la mer par ruissellement. Les bassins de rétention constituent une alternative pour une meilleure maitrise de l'eau dans le développement agricole. C'est le cas du bassin de Tiguéré Yéné à Matam.

L'exploitation des ressources en eaux souterraines est limitée par plusieurs contraintes, au nombre desquels on peut relever notamment :

- des remontées d'eau marine qui entrave la qualité des eaux et rendent nécessaire la construction de barrages de protection ;
- de fortes variations saisonnières et interannuelles des pluies qui exigent l'édification de structures de stockage à des coûts souvent élevés ;
- la limitation des possibilités d'irrigation gravitaire et le recours à des équipements coûteux pour le pompage et le drainage.

Il s'y ajoute, s'agissant spécifiquement des eaux souterraines, que les lacunes qui existent dans la connaissance de leur volume réel, leurs qualités géochimiques, leurs aptitudes pour les usages agricoles et humains ainsi que les conditions de recharge de ces ressources hydrogéologiques limitent la planification de leur utilisation rationnelle.

Le potentiel exploitable est estimé à 12,5 milliards de m^3 dont 10 milliards de m^3 dans les nappes phréatiques et 2,5 milliards de m^3 pour les nappes profondes du maastrichtien. Au niveau de ces deux types de nappes renouvelables et généralisées, l'eau est de bonne qualité.

Un outil de pilotage de l'irrigation

Le choix de l'outil de pilotage de l'irrigation s'est porté récemment sur la modélisation agrométéorologique du bilan hydrique afin de simuler la fraction d'eau du sol facilement disponible pour l'extraction racinaire (FTSW). Un modèle calibré et validé sur les variétés d'arachide Fleur-11 et GH-119-20 propose d'exprimer l'évapotranspiration en fonction du développement racinaire et foliaire du couvert ainsi que de l'état hydrique du sol et du climat (Sarr et al., 2004). Les fonctions établies dépendent de paramètres spécifiques à chaque variété considérée. Le pilotage de l'irrigation consiste en la traduction des doses d'irrigation nette par ajustement d'un scénario d'évolution de la FTSW. Au préalable, des recherches expérimentales sur les modalités d'irrigation en termes de doses et fréquences associées à un rendement et à une qualité de la production ont été conduites pour divers modes d'irrigation (aspersion, goutte-à-goutte, gravitaire) au profit du CNIA (Comité national interprofessionnel de l'arachide) (Sagarra, 2003). Une application dénommée Simarbhy a été développé par le CERAAS

(Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse), afin d'aider les producteurs à piloter leur irrigation. Ce travail a été entrepris dans le cadre du programme de relance de l'arachide de bouche et de diversification, du projet d'appui institutionnel du CNIA.

En outre, des travaux ont été réalisés sur l'analyse des contraintes des températures extrêmes en agriculture irriguée et sur la détermination des calendriers culturaux optimaux pour le riz irrigué à l'aide du modèle Ridev développé par l'ADRAO (Association pour le développement de la riziculture en Afrique de l'Ouest) et l'ISRA (Dingkhun et al., 1993).

4.5.2. Exploitation des terres

La plupart des problèmes environnementaux identifiés dans les différentes zones agroécologiques résultent du processus de dégradation des conditions climatiques (sécheresse) qui s'est accéléré depuis la fin des années 1960 (Zone Nord), mais aussi de l'impact des activités anthropiques (pression démographique, extension des cultures, développement des aménagements hydro-agricoles, etc.) qui se traduisent par une modification profonde des systèmes d'utilisation de l'espace et d'exploitation des ressources naturelles.

Les techniques de gestion durable des terres et de Défense et de Restauration des Sols ont été préconisées pour une utilisation durable des terres cultivées.

La réalisation des DRS nécessite la collecte et l'analyse de données topographiques, hydrologiques, climatiques, pédologiques, biologiques (flore/faune) et socio-économiques. Dans chaque situation étudiée, l'étendue des impacts sera mesurée en superficie atteinte et en ampleur de dégradation. Ce travail sur le terrain avant d'être reporté sur une carte d'analyse de l'état des lieux. L'application se fera à partir de procèdes biologiques ou mécaniques suivant les contraintes identifiées. Les procédés biologiques doivent aboutir à conférer au sol une résistance accrue à l'attaque hydrique ou éolienne en utilisant l'action de la végétation naturelle ou cultivée (techniques agroforestières). Les procédés mécaniques doivent quant à eux servir au contrôle du ruissellement par la réduction ou la suppression de la pente, permettant ainsi de réduire la vitesse des eaux et leur force d'entraînement de la couche superficielle du sol.

Les procédés mécaniques qui peuvent être utilisés :

- **Les Digues/diguettes :** Elles permettent de protéger les champs, les pistes et les villages contre les eaux de ruissellement et des crues de cours d'eau. Elles servent également à corriger les rigoles, les torrents et les ravines. Elles sont faites en différents matériaux : terre, gabions, pierres sèches,
- **Les Cordons pierreux :** Ce sont des alignements de pierres (de diamètre > 15cm) placées les unes contre les autres sur 2-4 rangées, disposées selon les courbes de niveau. Ils ont le même objectif de lutte antiérosive que les haies vives doublées de bandes herbacées : ouvrage filtrant pour freiner le passage de l'eau (le plus en amont possible) afin d'éviter une accumulation de trop de force (énergie) par la vitesse. La contrainte majeure est l'approvisionnement en pierres.
- **Les Haies vives :** Elles constituent une alternative économique aux clôtures mortes: elles économisent du travail et l'agriculteur peut en tirer des produits commercialisables: perches, fruits, etc.

- **Les Fascines :** Ce sont des obstacles à l'écoulement dans les rigoles et les ravines de faibles dimensions (< 1 m²). Les fascines doivent être construites bien à l'amont des premières manifestations de creusement liées au ruissellement concentré de l'eau. Elles sont constituées de branchages entrelacés entre les pieux biens ancrés, formant des petits seuils déversoirs entraînant le dépôt des sédiments en amont et permettant de rétablir le profil d'équilibre du chenal. La structure de base sera constituée de poteaux bien enfoncés et des troncs mis en travers de l'écoulement en les ancrant bien soigneusement dans les rives. La hauteur maximale de l'ouvrage ne dépassera pas les 2/3 de la hauteur du ravin.

4.5.3. Exploitation des ressources forestières

La dégradation des formations forestières en particulier, de la végétation en général constitue une des manifestations de la sécheresse dont les impacts sont aggravés par l'extension des zones de culture (défrichements, feux de brousse, etc.), la pratique de l'élevage extensif (surpâturage, élagage des ligneux, etc.) et la surexploitation des ressources forestières pour la production de charbon de bois. Plusieurs formations forestières se trouvent dans un état de dégradation avancé (cas des mangroves), d'autres formations spécifiques comme les forêts de Gonakié de la vallée du fleuve Sénégal ont quasiment disparu au cours de ces dernières années.

Le CSE produit régulièrement au cours de l'hivernage des cartes de la production végétale, obtenues à partir d'une corrélation entre l'indice de végétation par la différence normalisée (NDVI) dérivé par les mesures de réflectance spectrale acquises par le radiomètre AVHRR placé à bord des satellites NOAA (Martini et al., 2003). Une corrélation étroite a été mise en évidence entre l'indice de végétation par la différence normalisée et la quantité de biomasse herbacée et ligneuse mesurée sur le terrain en différents endroits du Sénégal. Pour prendre en compte les différents potentiels des écosystèmes sénégalais, l'état de fertilité du sol notamment, et pour séparer ainsi le signal météorologique du signal écologique, l'indice de végétation par la différence normalisée a été transformé en un indice de conditions de la végétation, ou VCI (Unganani et Kogan, 1998). Les valeurs de cet indice sont, en effet, étroitement en rapport avec les caractéristiques écologiques de chaque zone (sol, climat, végétation).

Ces résultats pourraient être exploités pour une gestion durable des ressources forestières.

4.6. Prévention et gestion des risques climatiques

La prévision des rendements des cultures vivrières constitue en zone semi-aride une préoccupation majeure pour les décideurs chargés de gérer et de contrôler les stocks céréaliers et de déclencher l'aide alimentaire en cas de calamités dues aux chocs climatiques. De nos jours, la prévision des rendements est conçue également comme un moyen efficace pour situer les zones de production excédentaire et faciliter la programmation des échanges de flux céréaliers nationaux et sous régionaux.

Les nouvelles technologies fondées sur la modélisation des cultures et les SIG constituent le fondement de ce système. Les simulations faites sur le mil sont basées sur la relation : rendement en mil (kg/ha) = 10,9 IRESP + 52,7. Une fonction régionale a été également développée à l'échelle des pays du CILSS : rendement en mil (kg/ha) = 11,3 IRESP – 128 (Sarr et Fall, 1997, 1998, 1999 ; Samba *et al.,* 2001). Ces relations permettent d'expliquer environ 70 % du rendement final en grain. Ce système a fait preuve d'une robustesse appréciable à l'échelle des unités administratives au Sénégal (figure suivante) et des pays du CILSS (Sarr et Fall, 1997, 1998, 1999 ; Samba *et al.,* 2001). En effet, le système actuel de suivi de la

campagne agricole, de prévision des rendements et d'alerte précoce au Sahel réalisé par le centre régional AGRHYMET trouve, entre autres, ses bases scientifiques et conceptuelles dans les résultats obtenus par la recherche dans les pays du Sahel en général et au Sénégal en particulier

Pour l'arachide, le modèle AraBHy a permis de prédire les rendements en gousses de l'arachide un mois avant la récolte avec une précision 90 % (Annerose et Diagne, 1990).

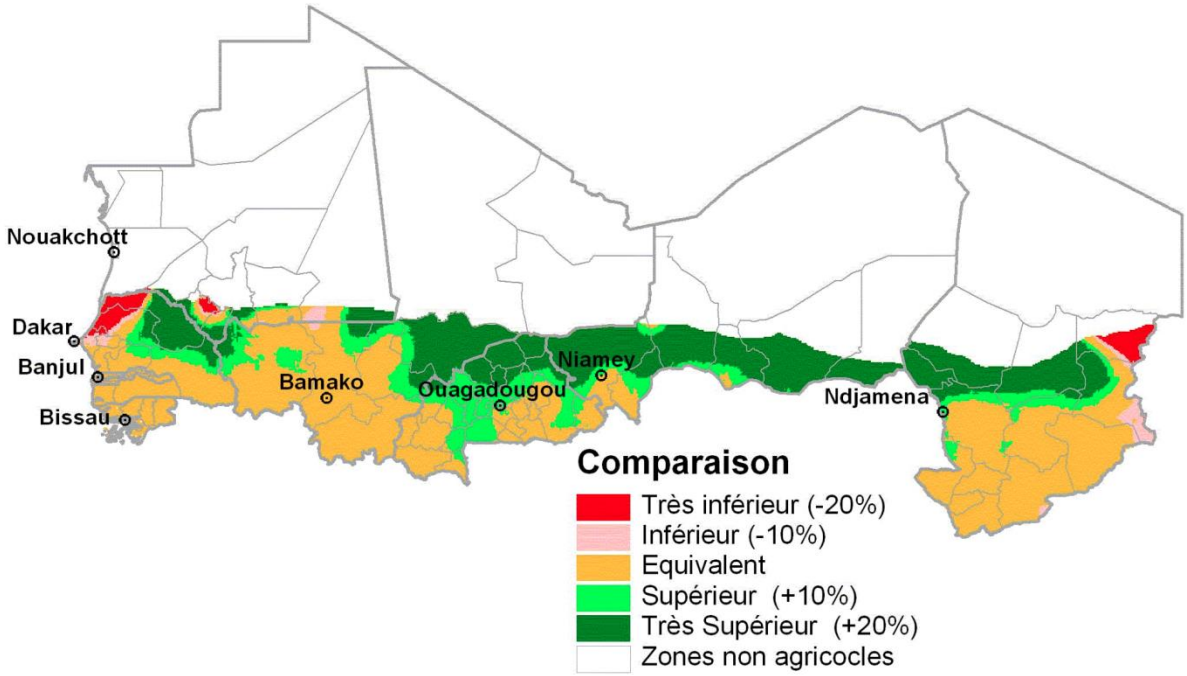


Figure 8: Rendements en grains simulés du mil par le logiciel DHC à l'échelle des pays du CILLS (Agrhymet 2003)

Des études de diagnostic hydrique et de zonage agro-climatique ont été également réalisées au Sénégal par Vanderchmitt (1989) ; Khalfaoui (1991) ; Diagne (1992) et Diop (1996). Ce zonage s'appuie sur une étude du risque agroclimatique à partir de données s'étalant sur une période de 30 ans. Les contraintes agroclimatiques sont ensuite traduites en termes de calendriers (date de début et de fin de saison, durée de cycles des cultures observée 8 années sur 10, calage optimal du cycle des principales cultures, détermination des cultures possibles dans les différentes zones agroécologiques du pays). Ce zonage se fonde également sur la simulation du bilan hydrique et la quantification d'indicateurs pertinents, tels que l'indice de rendement espéré pour un espace agricole donné, les dates de semis optimales permettant d'atteindre 8 années sur 10 une valeur maximale de l'indice de rendement espéré et l'analyse des potentialités de production d'une culture dans un espace donné. Le croisement de ces données a permis de déterminer des zonages et conduit à l'identification des zones à risque, la gestion des fonds de calamités au profit du CNIA et la carte variétale de l'arachide. Cette carte est toujours celle appliquée actuellement pour la culturge d'arachide au Sénégal. La variété d'arachide préconisée dans la partie Sud et Est du Sénégal (Tambacounda) est la variété 69-101 (Ndoye et Clavel, 1997). Il n'y a pas de recommandation spécifique pour la zone de Matam car cette zone n'est pas une zone de culture arachidière.

5. PROMOTION DE LA BONNE GOUVERNANCE DES RESSOURCES NATURELLES

5.1. Appui aux organisations paysannes.

L'une des forces principales du secteur agricole sénégalais aujourd'hui est l'émergence des organisations paysannes et leur influence croissante dans la prise de décision au niveau local et national. Grâce à leur dynamisme, elles sont en effet devenues des partenaires stratégiques pour le gouvernement et les bailleurs de fonds. Pour cela leurs participations actives dans les instances de décisions locales et dans la formulation des plans locaux de développement sont devenues incontournables. Cependant il est nécessaire d'appuyer la formation de leurs membres, en contribuant au renforcement de leurs capacités organisationnelles et à leur professionnalisation.

Le FIDA appuie la participation des structures faîtières des organisations paysannes dans les instances et forums régionaux où sont définies les politiques de développement, pour qu'elles puissent présenter le point de vue du monde rural et avoir ainsi une influence sur les décisions qui les touchent directement. Il s'agit de :

- renforcer les capacités des ruraux pauvres et de leurs organisations pour leur permettre d'exercer de nouvelles responsabilités, de prendre une part plus active à la concertation en matière de développement local tout en favorisant la participation des femmes dans la prise de décision;
- améliorer l'accès des ruraux pauvres aux marchés et aux services financiers, en facilitant l'accès aux savoirs et à l'information sur les possibilités de débouchés ainsi qu'aux services financiers de proximité nécessaires

Par ailleurs, les mécanismes d'échange multi-acteurs ont été également très déterminants dans le renforcement des processus techniques et méthodologiques concernant le transfert de technologies. Le contexte institutionnel est caractérisé par l'intervention, dans ce domaine, de l'administration centrale et régionale, des collectivités locales et des organisations paysannes. Les collectivités locales interviennent dans la gestion et le développement des ressources locales et jouent un rôle privilégié dans la maîtrise et l'exploitation des ressources en eau. Les organisations paysannes sont devenues des acteurs incontournables après le désengagement de l'Etat et le transfert des responsabilités de gestion. Il existe un potentiel de leadership et d'innovation technique et institutionnelle au niveau local dont la valorisation pourrait contribuer à améliorer l'efficacité et la gestion durable des ressources naturelles, surtout dans le contexte de changement climatique.

Les femmes jouent également un rôle important dans le système de gouvernance, donc l'analyse de la dimension genre dans la mise en œuvre des stratégies d'adaptation est également importante à prendre en compte. Les activités contrôlées par les femmes sont au cœur du dispositif d'adaptation. Il est important de mettre l'accent sur le renforcement de l'autonomie économique des femmes à travers les activités génératrices de revenus.

L'institutionnalisation des approches en matière d'appui aux stratégies d'adaptation passera également par une meilleure prise en compte de la problématique et des stratégies locales dans la définition des politiques locales. Ce qui nécessite un renforcement de capacités de ces derniers dans ce domaine.

En particulier, l'USAID soutient la conservation de la biodiversité, les services d'appui conseil aux entreprises naissantes et les politiques nationales qui promeuvent la croissance, l'environnement et la gestion des ressources naturelles. L'USAID et ses partenaires encouragent les collectivités locales et les Organisations Communautaires de Base (OCB) à utiliser des pratiques transparentes de gestion financière et de planification des investissements pour leurs futurs efforts de développement. Pour éviter la surexploitation des produits naturels, les dirigeants des collectivités locales sont formés pour pouvoir assumer leurs responsabilités en matière de gestion des ressources naturelles.

Depuis les politiques d'ajustements (milieu des années 80) on parle de fonction aux paysans organisés, sans forcément que des mesures d'accompagnement conséquentes soient mises en place. C'est dans ce contexte qu'évoluent actuellement les organisations paysannes aussi bien au niveau des villages qu'au niveau inter villageois voir parfois nationale.

C'est dans la mesure où des responsables paysans seront progressivement associés à toutes les étapes des activités les concernant que pourront d'établir les conditions d'un dialogue et d'une confrontation équitables.

6. IDENTIFICATION DES BESOINS EN TECHNOLOGIES DANS LA ZONE D'ETUDE

6.1. Identification des besoins en recherche/développement

Les besoins en recherche/développement dans le domaine des changements climatiques ont été identifiés à partir du diagnostic fait sur les contraintes des zones concernées par cette étude. La plupart des projets de recherches/développement ont été réalisées sur la base de projets et programmes financés par les bailleurs avec des priorités différentes. Et rares sont les thématiques de recherches qui touchent les contraintes locales mais plutôt au niveau national.

Notre étude s'est basée sur la revue bibliographie, les différents documents de plan Locaux de développement qui ont été élaborés par les communautés à la base pour identifier les besoins en recherche/développement.

Cependant, il est difficile de passer à la hiérarchisation des priorités, car cela nécessite une concertation avec les populations de bases et avec les différentes couches (hommes, femmes et jeunes). Mais aussi la participation des autorités locales et les structures de développement. Cause pour laquelle la hiérarchisation des besoins n'a pas été tenue en compte dans cette étude.

Tableau 6: Besoins en Recherche/Développement pour une adaptation des systèmes agricoles face aux changements climatiques dans la zone d'étude

Secteur	Contraintes à lever	Recherche/Développement à promouvoir	Zone concernée	Institution porteuse
Agriculture				
	Faible productivité des céréales (sorgho et mil)	Conduire des études de sélection afin d'analyser les réponses des sorghos photopériodiques ou non à la variabilité des pluies. Leur indice de rendement espéré (IRESP) est moins stable et systématiquement plus faible à tous les niveaux de probabilités considérés. Dans ce contexte, la réintroduction de variétés photopériodiques, mieux adaptés à la variabilité des pluies, pourrait présenter des avantages agronomiques multiples.	Zone nord : Matam, Kanel	ISRA
		Recherche variétale pour améliorer l'hallélopathie du sorgho et permettre une culture en rotation.	Zone Nord et Sud	ISRA
		Recherche de variétés de mil et de sorgho et de maïs hybride à haut potentialité de rendements	Zone Sud : Tamba Goudiry	ISRA
Elevage				
	Améliorer la qualité et la disponibilité des ressources fourragères	Sélection d'espèces fourragères (annuelles et pérennes) susceptibles de produire des rendements élevés, de rivaliser avec les mauvaises herbes	Zone Nord	ISRA/LNERV et CNRF
	Optimisation de l'intégration de l'élevage dans les systèmes de culture	Outils de la Modélisation : Tester à moindre coût l'introduction de nouvelles techniques (embouche bovine, fertilisation combinée engrais organique et minéral, couverture des tas de fumier, etc…) sur le fonctionnement globale d'une ferme et sa durabilité. Faire une simulation et une quantification des biomasses recyclées (résidus de cultures, engrais de ferme) et des exports/imports de biomasses vers les	Zone Sud : Goudry	ISRA/LNERV et CNRF

		fermes (vente des fanes d'arachide, achat de compléments alimentaires) afin de calculer les indicateurs techniques, environnementaux (bilan de nutriments) et économiques (calcul marges brutes et revenus) permettant d'optimiser ce système.	Zone Nord et Sud	ISRA/LNRPV
	Promouvoir des recherches sur la fertilisation localisée des cultures	Des options d'amélioration des pratiques culturales peuvent être poursuivies et optimisées. Le développement de la technologie de Placement Profond de l'Urée pour fertiliser les plants de riz irrigué devrait être élargi à d'autres spéculations céréalières (maïs, riz pluvial, Sorgho). Cette technologie permettra une utilisation raisonnée des fertilisants chimiques et réduirait considérablement les émissions de GES. Elle permettra également d'optimiser les rendements des cultures	Zones nord et sud	ISRA/LNRPV CRA St Louis
	Renforcer les capacités de prévision et d'anticipation climatique.	Améliorer la prévision agricole par modélisation, pour permettre aux décideurs et à leurs partenaires d'intervenir pour corriger ou compenser les situations dues aux facteurs agroclimatiques défavorables.	Zones nord et sud	ISRA, ANACIM

6.2. Identification des besoins en transfert de technologies dans la zone d'étude

Les besoins de transfert de technologies sont résumés dans les tableaux 7, 8 et 9 suivants.

Tableau 7: Technologies à promouvoir dans la zone pour une adaptation des systèmes l'agricoles face aux changements climatiques

Secteur	Problématique	Technologies	Zones	Cibles /Acteurs
Agriculture				
	Amélioration de la productivité par une gestion durable des terres cultivées	Technologie de l'agriculture de conservation Objectif : Assurer une perturbation minimale des sols, associée au maintien d'un couvert végétal annuel et à la rotation des cultures, de préférence en incluant des légumineuses pour améliorer la teneur des sols en azote	Zone sud : Goudiry, Bakel	Petits producteurs céréales
		Technologie de fertilisation raisonnée Objectifs : Adopter une fertilisation raisonnée qui tient compte des besoins nutritionnels des cultures et de la gestion intégrée de l'eau sans polluer l'environnement	Zone Nord et Sud	Producteurs
		Banque de semences améliorées Objectifs : Rendre accessible les semences améliorées par la mise en place de banques de semences communautaires	Zone Nord et Sud	Organisations de producteurs
	Améliorer l'accessibilité des semences améliorées et adaptées aux zones agro écologiques	Adoption de nouvelles cultures pour une plus grande diversification Objectif : Promouvoir l'arboriculture fruitière (banane), le maraîchage (patate douce) et de nouvelles variétés céréalières (sésame, fonio), en ajustant les périodes des semis et des récoltes en fonction de l'information climatique	Zone Nord et Sud	Petits Producteurs
	Intégration de l'élevage dans les systèmes de culture	Système intégrée agriculture/élevage Objectifs : Promouvoir l'utilisation des terres marginales pour les cultures	Zone Sud	Producteurs

	pour réduire la vulnérabilité des ménages	fourragères (mélanges persistants de graminées/légumineuses sur ces terres), pour stopper l'érosion et enrichir les sols épuisés et les terres non arables et pauvre en matière organique. En outre, le développement de l'élevage dans des zones à sol relativement peu fertile permettra la production de plus grandes quantités de fumier de ferme pour la culture des terres arables.		
	Gouvernance des ressources naturelles	Système d'alerte précoce Objectif : Améliorer la planification et la gestion des risques, sinon mettre en place un système de gestion et de prévention des risques et des catastrophes naturelles ; Améliorer les systèmes d'alerte agro-météorologique, des plans d'urgence en cas de sécheresse, des interventions en cas de crue, de la sensibilisation, de l'assurance des risques indexée sur les conditions météorologiques	Zone Nord et Sud	Collectivités locales, OCB

Tableau 8: Technologies à promouvoir dans la zone pour une adaptation des systèmes d'élevage face aux changements climatiques

Secteur	Problématique	Technologies	Zones cibles	Populations cibles
Elevage	Mise en place de Parcs améliorés.	Régénération des parcours (insémination des parcours) et prévention des incendies. Il s'agit de transformer certains parcours en réserves consacrées à la production de fourrage et au pâturage contrôlé	Zone nord	Eleveurs, agriculteurs, OCB
	Gestion des parcours	Promouvoir les technologies de Supplémentation animale (Raval 2, 4, ect.)	Zone Sud et Nord	Groupements d'éleveurs

	Amélioration de l'alimentation des animaux	Promotion des cultures fourragères.	Zone Sud et Nord	Producteurs
		Constitution et conservation de réserves fourragères	Zone Sud et Nord	Éleveurs

Tableau 9: Technologies à promouvoir dans la zone pour une gestion durable des ressources naturelles

Secteur	**Problématique**	**Technologies**	**Zones cibles**	**Populations Cibles**
Ressources Naturelles	Captage et valorisation des eaux de pluie par les bassins de rétention et promotion des cultures irriguées	Collecte des eaux pluviales avec des techniques traditionnelles et des nouvelles technologies	Zone Nord et Sud	Agriculteurs/ Collectivités locales
	Technologies de Lutte anti érosive (brise vent, haie vives).	Assurer une conservation des sols et des eaux par un encadrement des agriculteurs pour l'utilisation des techniques économes d'eau (demi-lunes).	Zone Sud	Producteurs
		Les espèces préconisées dans la zone Sud pour les haies sont les Acacias (*holosericea, occidentale, indiça*) *Eucaluptus camaldulensis* et le *Prosopus juliflora* ; dans la zone nord *E. camaldulensis*		
	Gestion des ressources forestières	Promotion de la foresterie communautaire et privée à travers l'incitation aux plantations de production de bois d'œuvre et de chauffe et l'agroforesterie	Zone Sud	Collectivités locales
		Impliquer davantage les citoyens dans la gestion des ressources forestières et planifier une exploitation rationnelle de ces dernières (exploitation du charbon)	Zone Sud	Collectivités locales
		Promotion de l'éducation environnementale afin de créer une conscience environnementale au niveau de la génération montante	Zone Nord et Sud	GIE de Jeunes

6.3. Analyses des barrières liées à la diffusion et au transfert de technologie dans la zone d'étude

Le tableau 10 résume les contraintes liées à la diffusion des technologies en milieu rural.

Tableau 10: Identification des barrières liées à la diffusion des technologies. (le tableau modifié tient compte de la hiérarchisation des barrières)

Agriculture de conservation	Faible niveau de connaissance ; Faible niveau de recherche/développement	Procéder à la démonstration et à la diffusion des technologies auprès des utilisateurs par l'installation des champs de démonstration et les visites d'échanges entre producteurs
Technologie de fertilisation raisonnée	Faible maîtrise de la technologie Faible niveau de diffusion Absence de formation des producteurs	
Banque de semences améliorées	Absence de réseau fiable de distribution ; Faible expertise technique et de compétence humaine au niveau de la filière semencière Manque de planification à long terme; Manque de financement	Mettre en place une plateforme collaborative regroupant les différents acteurs du système et la formalisation du partenariat entre ces derniers
Diversification des cultures	Manque de sensibilisation et de formation des producteurs ; Absence d'information sur les possibilités de marchés Faible maîtrise des cultures associées Faible disponibilité de l'eau	Favoriser l'accès à l'eau d'irrigation par la mise en place de forages ou de bassins de rétention.
Intégration agriculture élevage	Non accès à la terre des éleveurs (problème de gestion du foncier) Faible diffusion de cette technologie Manque de sensibilisation et de formation des acteurs, Manque d'organisation des éleveurs	Elaborer de manière participative des plans locaux de développement et des cadres de concertation dynamiques; Intégrer les cultures fourragères pour améliorer l'alimentation du bétail et aller vers un élevage semi intensif

Gestion des parcours	Non prise ne compte du changement climatique et de la perte de biodiversité Absence de diffusion de l'information à la base Nécessité de réactualiser les données élaborés par le CSE devraient être réactualisés de manière régulière	Elaborer des cartes d'occupations des sols réactualisées et veillez au respect des zones définit pour les parcours du bétail et pour les agriculteurs ; Délimitez et baliser les zones de parcours du bétail et veiller à leur respect strict ; Promouvoir l'agroforesterie et l'ensiment de certain parcours
Mise en place de réserves fourragères	Absence de matériels adaptés à la récolte du fourrage; La technologie est disponible mais on note une absence de vulgarisation et de sensibilisation au niveau des acteurs	Appuyer la professionnalisation et la responsabilisation des organisations des éleveurs pour leur permettre de jouer un rôle dans le transfert et l'adoption de technologies adaptées ;
Supplémentation du bétail	Sous équipement et faible niveau de technicité des éleveurs.	Développer un système de formation et sensibilisation des éleveurs
Captage et valorisation des eaux de pluies	Insuffisance et manque de capacités techniques	Multiplier les bassins de rétention et mettre en place un comité de gestion pour prévenir les conflits
Technologie de Lutte anti érosive	Absence de vulgarisation et de sensibilisation des producteurs	Procéder à la démonstration et à la diffusion des technologies auprès des utilisateurs par l'installation des champs de démonstration.
Promotion de la foresterie communautaire et privée.	Faible niveau de technicité disponible	Renforcement de capacités des OCB dans ce domaine

Hormis les barrières propres à chaque technologie, il existe des barrières transversales à l'ensemble des technologies. Il s'agit, entre autres, de la difficulté d'accéder aux financements, du passage du stade de recherche/développement au stade de diffusion à grande échelle, des obstacles pour la démonstration et la promotion des nouvelles technologies, de l'absence de planification à long terme.

Dans la plupart des situations, la mise en œuvre des projets et programmes a permis de créer un environnement favorable mais qui, pour la plupart est demeuré « artificiel », disparaissant généralement avec la fin des projets et programmes, ce qui pose la question de durabilité et d'absence de planification. De plus, on note une faible expertise technique et de compétence humaine au niveau de la diffusion des technologies. La formation et les partenariats en matière de recherche avec les institutions publiques s'imposent. Les avantages à long terme de tels partenariats devraient profiter au secteur privé ou aux ONG à travers la formation d'experts techniques et de spécialistes qui contribueront au développement efficace.

6.4. Stratégies à mettre en œuvre dans le domaine de la vulgarisation

La transition des systèmes de production actuels vers des systèmes plus durables permettant une optimisation des rendements et une meilleure conservation de l'environnement présente de nombreux défis :

- la participation de la communauté dès le début, c'est à dire la planification à la mise en œuvre (démarche participative) ;
- la disponibilité des terres et la garantie des droits d'utilisation des terres et des droits fonciers ;
- la nécessité de formations et de renforcements des capacités dans l'utilisation des technologies et de ses bénéfices ;
- l'appui au développement communautaire à la base ;
- l'appui à la professionnalisation et la structuration des filières ;
- l'appui à la reconstitution de circuits commerciaux et des opérateurs privés ;
- le développement d'un système de formation des différents acteurs de la filière en renforçant la liaison recherche/diffusion et en veillant à ce que les activités de R&D et de démonstration soient mieux pilotées et reliées davantage aux activités de promotion et de lancement sur le marché.

Nécessité de la mise en place d'un plan de communication et de diffusion des technologies

Les mesures environnementales pour le développement durable, liées à l'adaptation au changement climatique, à la gestion des bassins versants, à la gestion des risques de catastrophes, au développement territorial participatif, etc., nécessitent la mise en place de processus, d'outils et de méthodes de communication pour la sensibilisation, le partage des connaissances et la participation communautaire. De plus en plus, la mise en œuvre de stratégies et d'activités de communication sont mises en place pour le développement dans les domaines de la gestion des ressources naturelles (GRN), de la sécurité alimentaire et de l'amélioration des conditions de vie en milieu rural.

L'approche développée par la FAO pourrait être préconisé. Elle associe divers processus et outils de communication participatifs, allant de la radio rurale aux Technologies de l'Information et de la Communication (TIC). L'application systématique de stratégies et de services de communication sur le terrain contribue à l'utilisation durable des ressources naturelles et offre de nouvelles opportunités de développement pour les zones rurales par : i) la facilitation à l'accès équitable au savoir et à l'information pour améliorer les moyens de subsistance en milieu rural; ii) la promotion de la participation des populations et la collaboration en matière de GRN; iii) l'amélioration des capacités des institutions de développement; et iv) l'appui à la recherche novatrice et aux services consultatifs.

7. LEÇONS TIREES DES EXPERIMENTATIONS REALISEES DANS LA ZONE D'ETUDE

Différents projets et programmes se déroulent dans le pays pour limiter les risques climatiques dans certaines zones du pays. La mise en œuvre de ces projets ne peut être durable que lorsque les stratégies locales d'adaptation portées par les organisations paysannes sont viables, efficaces et efficients. Pour cela l'approche développée par la mise en œuvre de ces programmes demeure très importante. Quelques exemples de projets mis en œuvre dans la zone d'étude peuvent être cités comme des exemples réussis. Parmi ces programmes nous avons :

Le Projet de Développement Agricole de Matam (PRODAM) : En plus des réalisations effectuées sur la diversification des cultures avec l'introduction de la riziculture hivernale et des unités pastorales, le PRODAM a favorisé l'organisation des acteurs autour de groupements d'intérêt économique (GIE) qui permettra de pérenniser ces activités et de contribuer à la résolution de la problématique locale de développement. Dans la seconde phase, ce projet a permis de faciliter l'accès aux marchés en améliorant la compétitivité par une professionnalisation des acteurs.

Le Projet de sécurisation de l'élevage pastoral dans la région de Matam a été centré sur l'amélioration de l'accès à l'eau avec la création d'ouvrage hydraulique. Il s'agit d'un exemple réussi de gestion des ressources naturelles par la gouvernance locale. Il accompagne les éleveurs de la zone pour une meilleure gestion de l'espace et des ressources en eau et en fourrage. Dans ce cadre une charte locale a été élaborée pour une meilleure préservation et exploitation de l'écosystème sylvopastoral. Cette charte a permis de renforcer l'implication des organisations communautaires de base dans la gouvernance locale, de mettre en place un dispositif concerté et largement participatif de gestion d'un espace pastoral en lien avec le forage et les villages installés et de renforcer le rôle des femmes dans la dynamique de développement.

Le Projet d'Actions Concrètes sur le Changement Climatique avec Agronomes et Vétérinaires Sans Frontières a mis l'accent sur la gestion des ressources naturelles en réduisant la pression sur la ressource ligneuse. Un Système Pastoral d'Alerte et d'Information (SPAI) a permis, au préalable, de faire un diagnostic des informations prioritaires par catégories d'acteurs et de choisir des canaux d'informations sur l'état et l'abondance des ressources pastorales les plus pertinents à mettre en place. L'accessibilité à ces informations constitue une aide à la décision pour les pasteurs. Ces informations peuvent être vitales pendant les années sèches et permettent une meilleure gestion des ressources naturelles au niveau de la zone. L'approche multi acteurs est développée avec l'intégration des collectivités locales, les organisations de producteurs, les organisations communautaires de base, les éleveurs et les partenaires du développement ainsi que les institutions régionales du Ferlo ;

Le Programme de Gestion Durable et Participative des Énergies Traditionnelles et de Substitution avait pour objectif de réaliser des plans d'aménagement des massifs forestiers. Conscient de l'importance des interrelations entre agriculture, élevage et formations forestières, le projet a opté pour la réalisation de plans d'aménagement intégrés permettant une exploitation rationnelle avec moins de risque de conflits. La première phase du projet a été déroulée dans la région de Tambacounda et la seconde phase sera élargie à la région de Matam ;

Le Projet d'appui à la conservation de la biodiversité de la Réserve de Biosphère du Ferlo vise le renforcement des politiques et programmes de développement durable des ressources naturelles et de l'environnement mis en œuvre jusque-là dans les départements de Ranérou et Kanel.

Le projet USAID Yaajende vise à améliorer la sécurité alimentaire et nutritionnelle des populations par une programmation intégrée de l'agriculture, de l'agro-industrie, de l'élevage, de la nutrition et de la gouvernance ;

Le Projet d'Amélioration de la sécurité Alimentaire et d'appui à la Mise en Marché dans la région de Matam vise à améliorer la productivité des exploitations agricoles ciblées sur le riz, le maïs et les cultures maraîchères de niche et la promotion de la valorisation et la mise en marché des productions agricoles ciblées. C'est un projet novateur qui s'inscrit dans une démarche intégrée en mettant en exergue quatre composantes majeures qui sont : i) le renforcement de capacités des acteurs (producteurs, services d'appui conseil et conseillers ruraux) ; ii) la réhabilitation et l'extension de 1270 ha dans les communautés rurales de Nabadji Civol et Bokidiawé et de 750 ha de cultures de décrue ; iii) l'appui au Développement local par la mise en place d'un fonds d'investissement pour les infrastructures communautaires, d'appui à la mise en marché mais aussi d'appui au secteur privé par la promotion d'entrepreneurs ruraux ; iv) la coordination et la gestion du projet par la mise en place d'une UGP au niveau de la SAED/Matam. Dans le Walo, le projet vise la transformation progressive des parcellaires familiaux des années 80 en des exploitations agricoles rentables tournées vers la sécurité alimentaire et le marché, autogérées par des membres de GIE /OP renforcés et autonomes. Dans le Diéri, le projet vise le renforcement des infrastructures de marché, de commercialisation et de transformation des produits au niveau de quelques localités.

8. CONCLUSIONS ET RECOMMANDATIONS

La plupart des projets et programmes ont développé une approche multi-acteurs qui a permis d'apporter de la valeur ajoutée pour la durabilité et la diffusion des pratiques locales d'adaptation. Les réponses durables aux changements climatiques nécessitent la mobilisation de toutes les connaissances disponibles. Ainsi, l'adoption d'une approche mettant à contribution l'ensemble des acteurs concernés, est une démarche nécessaire dans un processus d'identification et de mise en œuvre de stratégies locales d'adaptation efficaces, efficientes et durables, qui constituent un phénomène multidimensionnel.

Dans cette perspective, il est nécessaire, pour l'implantation de nouveaux programmes et projets, de favoriser les échanges et le partage des expériences pour, d'une part, améliorer les solutions techniques et, d'autre part, renforcer les connaissances de manière horizontale (entre communautés et entre ces communautés et agents techniques (chercheurs, agents de vulgarisation) et verticale (vers des échelles d'échanges différentes comme vers les décideurs).

8.1. Sélection et amélioration variétale

- Améliorer la productivité du sorgho en réintroduction de variétés photopériodiques, mieux adaptés à la variabilité des pluies, pourrait présenter des avantages agronomiques multiples ;
- Faire des études permettant de réduire les teneurs en composés phénoliques par voie génétique, soit d'éviter l'effet allélopathique du sorgho;
- S'orienter vers des variétés céréalières plus productive (variétés hybrides)

8.2. Élevage

- Améliorer la disponibilité des fourrages, en intégrant les cultures fourragères dans les systèmes de production pour aller vers des systèmes intégrés.
- Vulgariser les systèmes de haies anti-érosives de différentes espèces préconisées par la recherche en privilégiant une démarche participative. Les espèces suivantes pourraient être diffusées : *Pennisetum purpureum*, arbustes fourragers comme le Leuceana *leucocephala, le Calliandra calothyrsus* et *Acanthus pubescens).*
- *Promouvoir les technologies de réserves fourragères et le développement de l'élevage semi intensive et privé;*

8.3. Intégration agriculture/Élevage

- Favoriser l'accès des éleveurs à la terre;
- Promouvoir la constitution et la conservation de réserves fourragères
- Planifier la régénération des parcours (ensemencement des parcours, gestions des parcs par une meilleure prévention des feux par les comités de veille villageois) ;
- Transformer certains parcours en réserves consacrées à la production de fourrage et au pâturage contrôlé

8.4. Gestion des resources naturelles

- Mettre en place des ouvrages de collecte et de stockage des eaux de pluies qui se perdent dans la mer par ruissellement. Les bassins de rétention constituent une alternative pour une meilleure maitrise de l'eau dans le développement agricole et aller vers une gestion intégrée de ces bassins pour le développement de cultures maraîchères, de la pisciculture et de l'élevage) ;
- Dans cadre du fleuve Sénégal, préconisant des méthodes de lutte intégrée comme la lutte mécanique qui peut-être combinée à la promotion de la valorisation économique de la végétation collectée pour les plantes envahissantes comme le typha dans la zone . Favoriser l'utilisation comme combustible (bio méthanisation ou pour faire du biocharbon), ou comme matériaux de construction, pour la fabrication de papier, etc.) ;
- Assurer une conservation des sols et des eaux par un encadrement des agriculteurs pour l'utilisation des techniques économes d'eau (demi-lunes
- Promotion de la foresterie communautaire et privée à travers l'incitation aux plantations de production de bois d'œuvre et de chauffe et l'agroforesterie
- Promotion de l'éducation environnementale afin de créer une conscience environnementale au niveau de la génération montante

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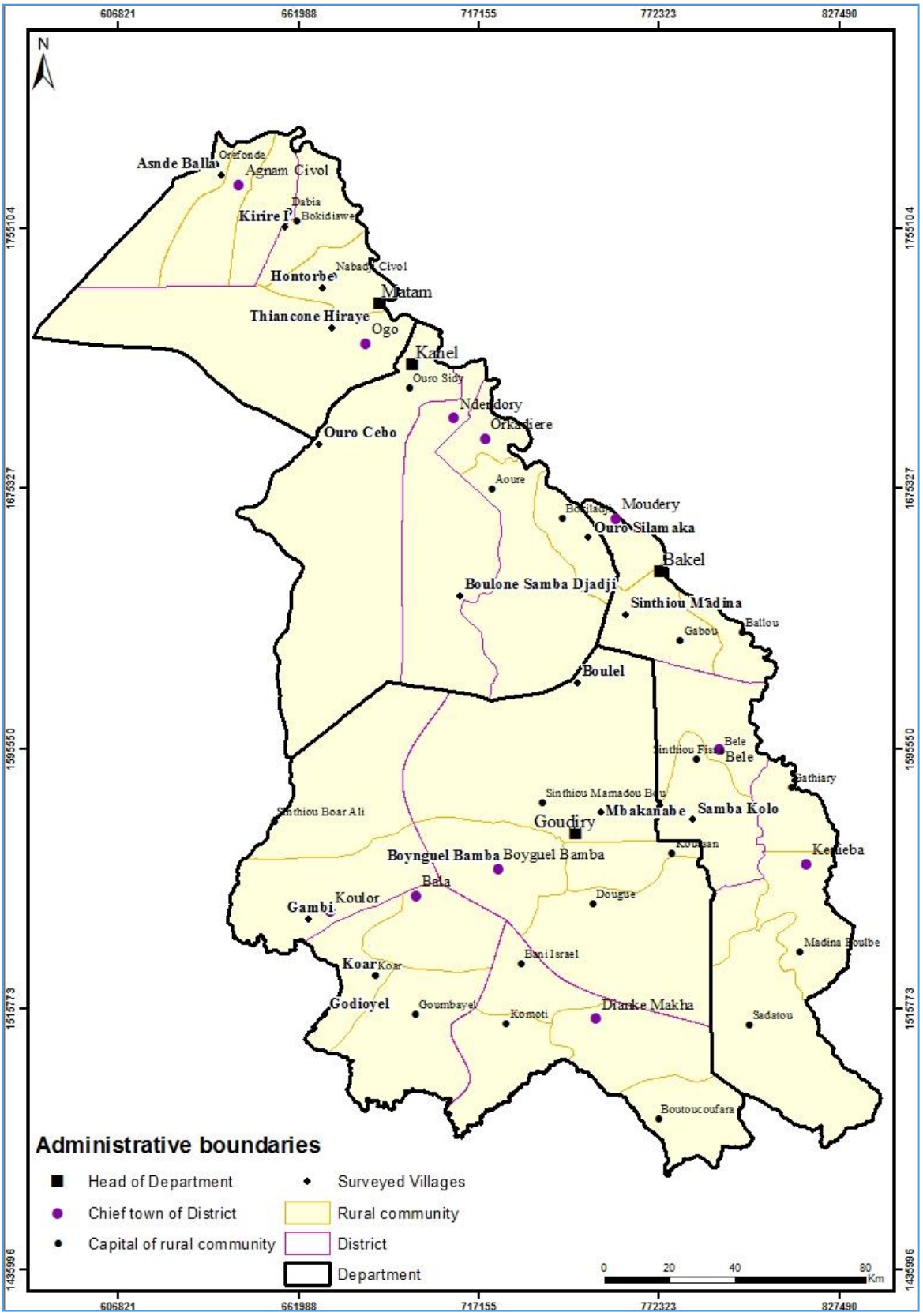
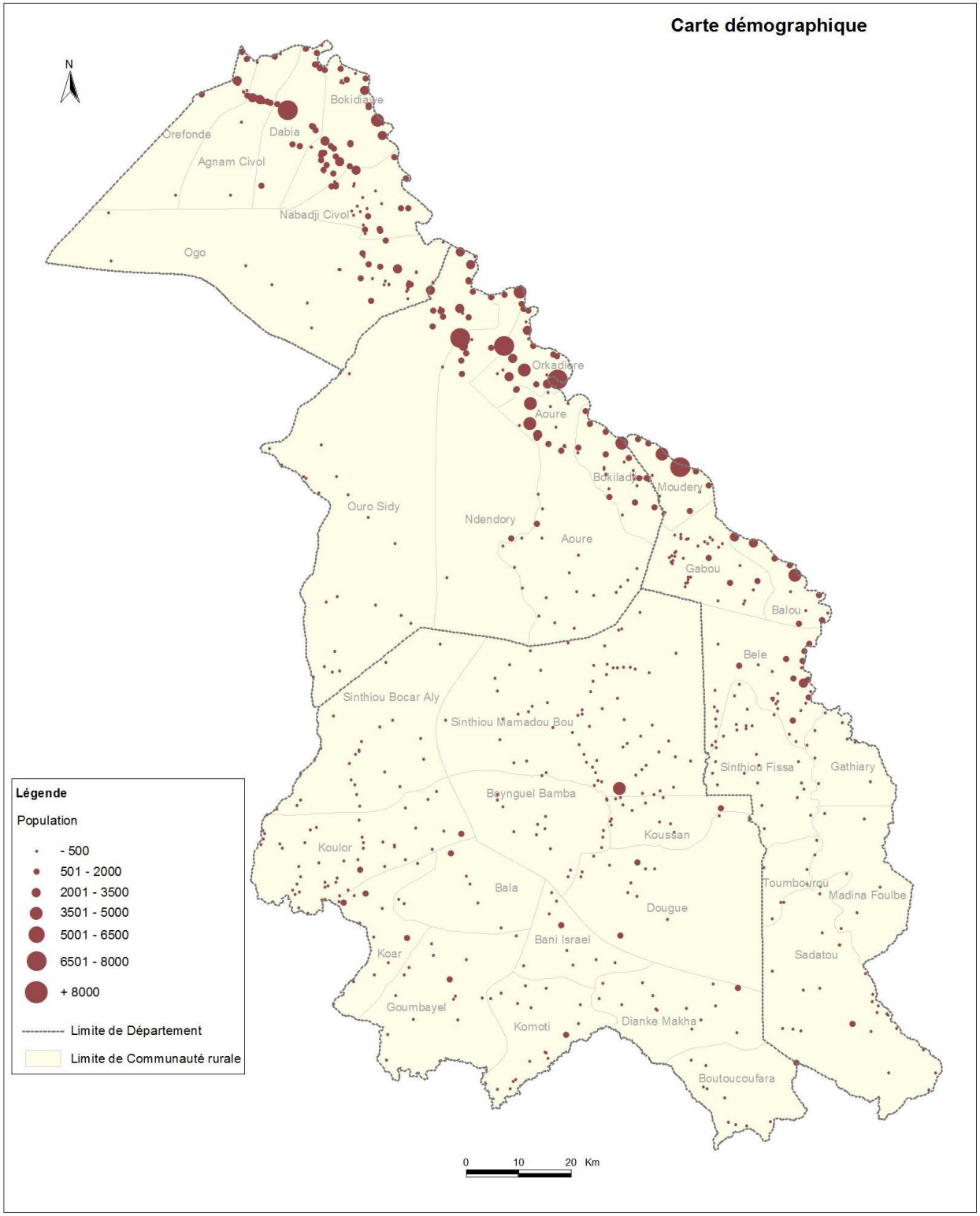
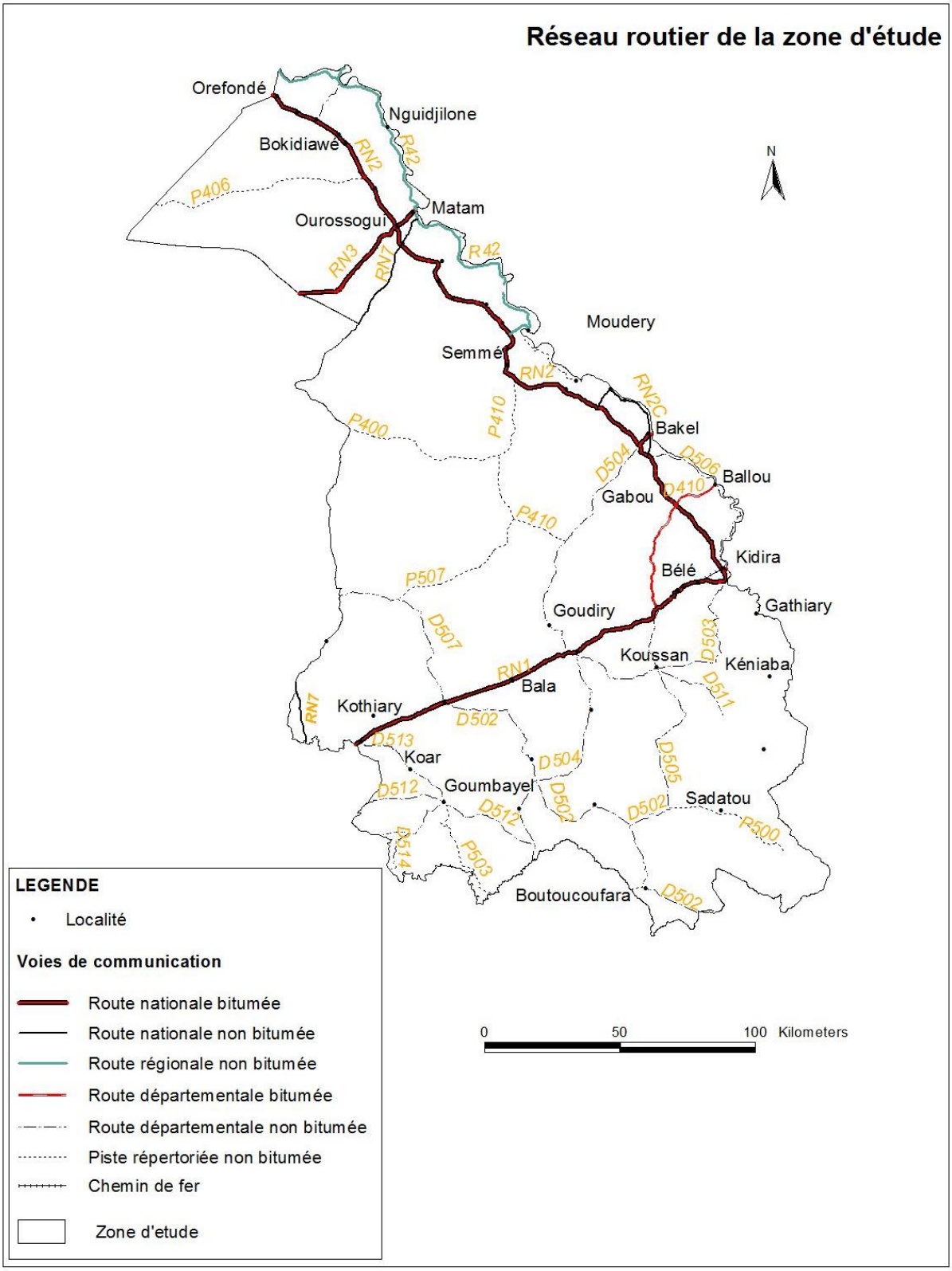
ANNEX M. ADDITIONAL MAPS OF THE ASSESSMENT REPORT

MAP 1: ADMINISTRATIVE UNITS AND SURVEY VILLAGES OF THE STUDY ZONE

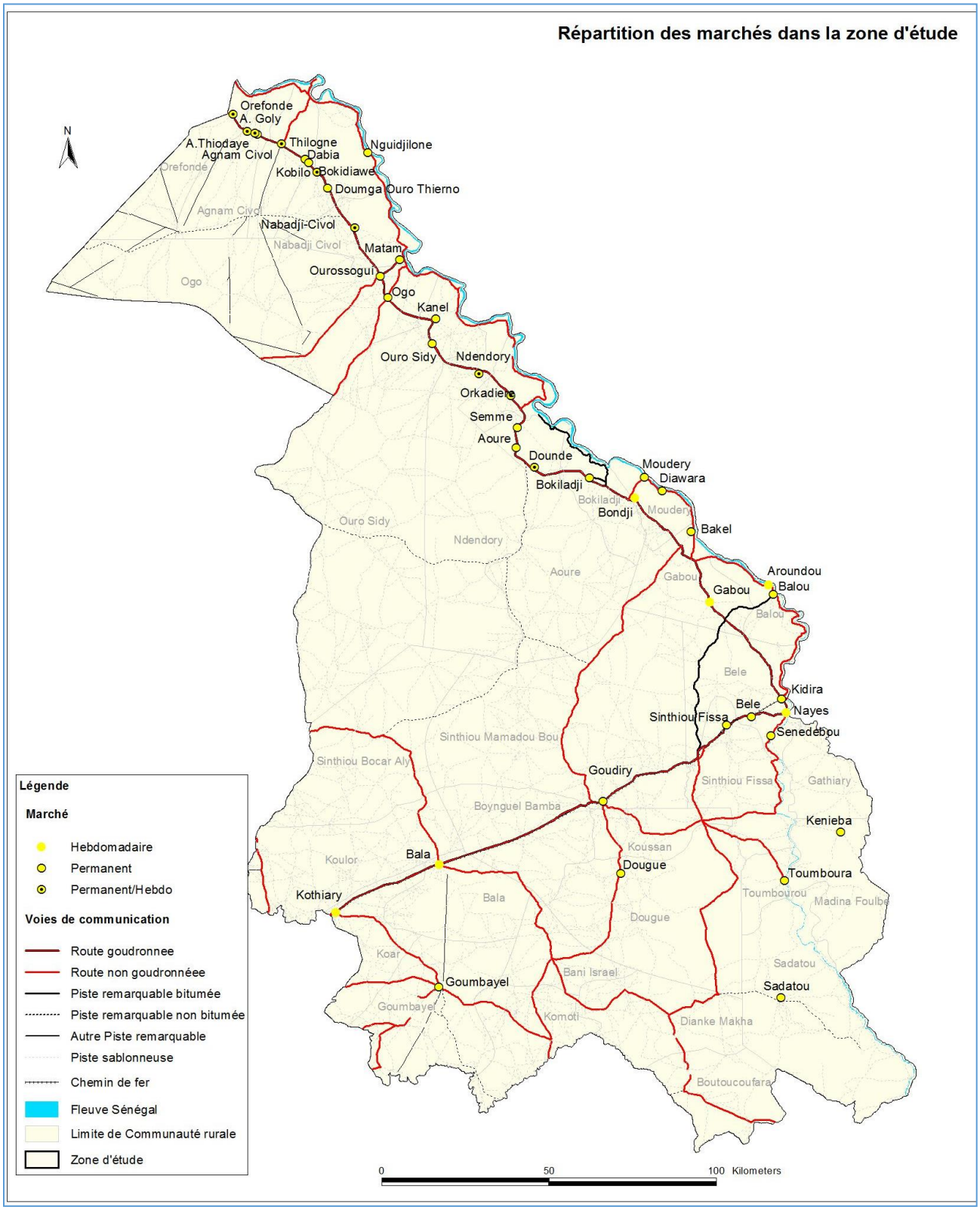


MAP 2: DENSITY OF HABITATION CENTERS OF THE STUDY ZONE

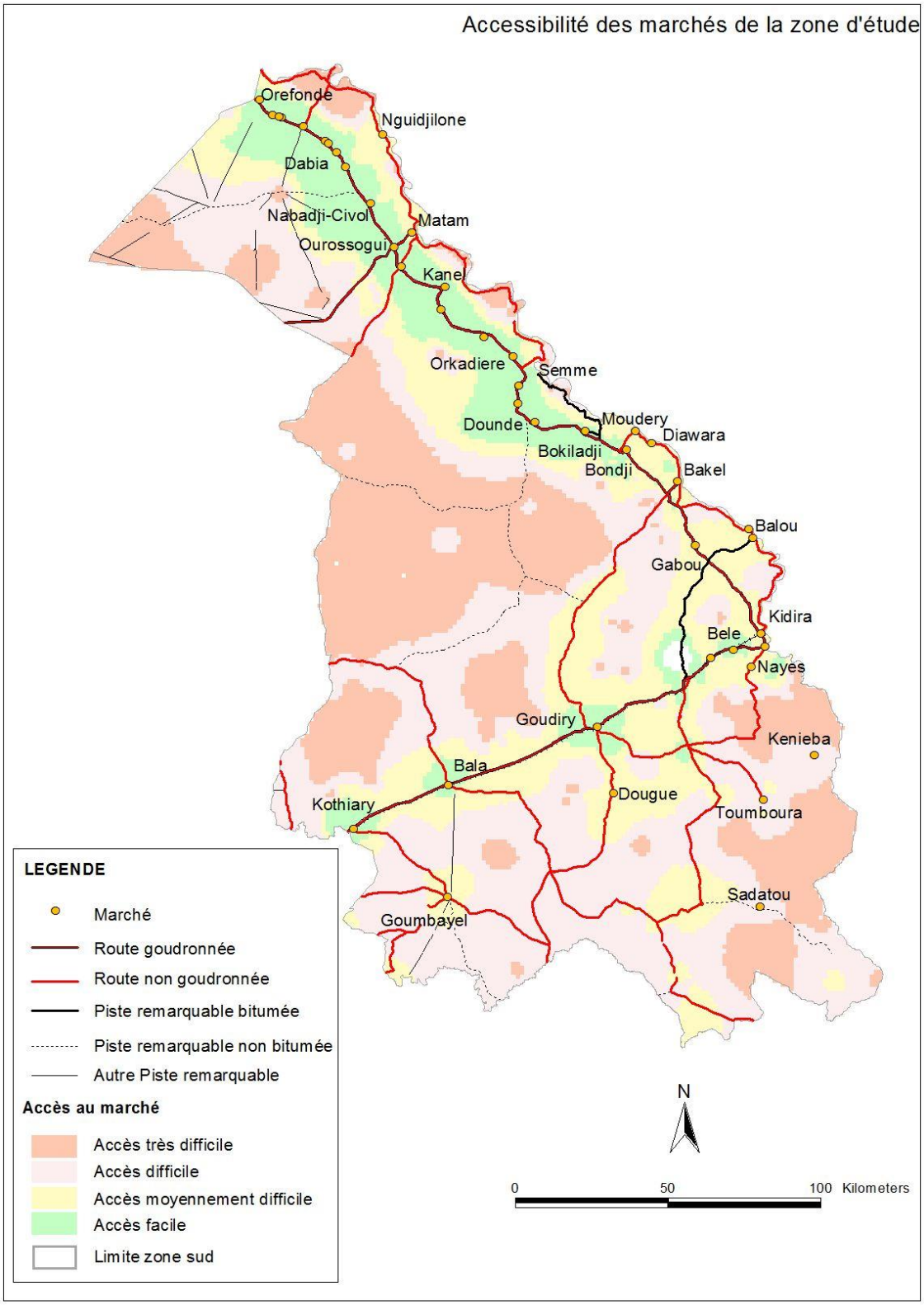



Réseau routier de la zone d'étude
Orefondé
Nguidjilone
Bokidiawé
RN2
R42
P406
Matam
Ourossogui
RN3
RN7
R42
Moudery
Semmé
RN2
RN2C
P410
P400
Bakel
D504
D506
Ballou
D410
Gabou
P410
Kidira
Bélé
P507
Gathiary
Goudiry
D507
D503
Koussan
Kéniaba
RN1
Bala
D511
RN7
Kothiary
D502
D513
Koar
D504
D505
Goumbayel
D512
D502
D512
D502
Sadatou
P500
D514
P503
Boutoucoufara
D502
N
0
50
100
Kilometers
LEGENDE
Localité
Voies de communication
Route nationale bitumée
Route nationale non bitumée
Route régionale non bitumée
Route départementale bitumée
Route départementale non bitumée
Piste répertoriée non bitumée
Chemin de fer
Zone d'etude

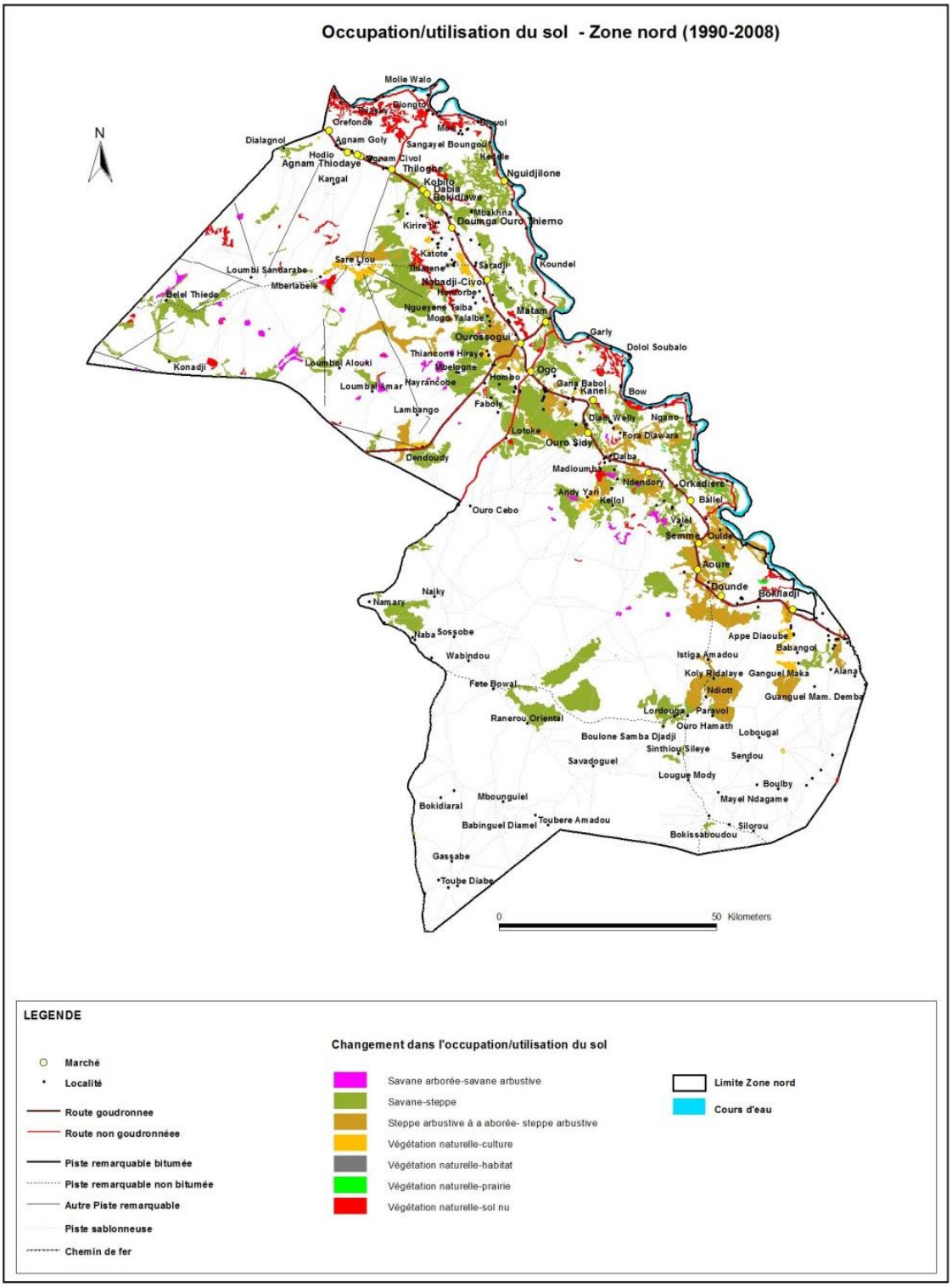
MAP 4: MARKETS OF THE STUDY ZONE



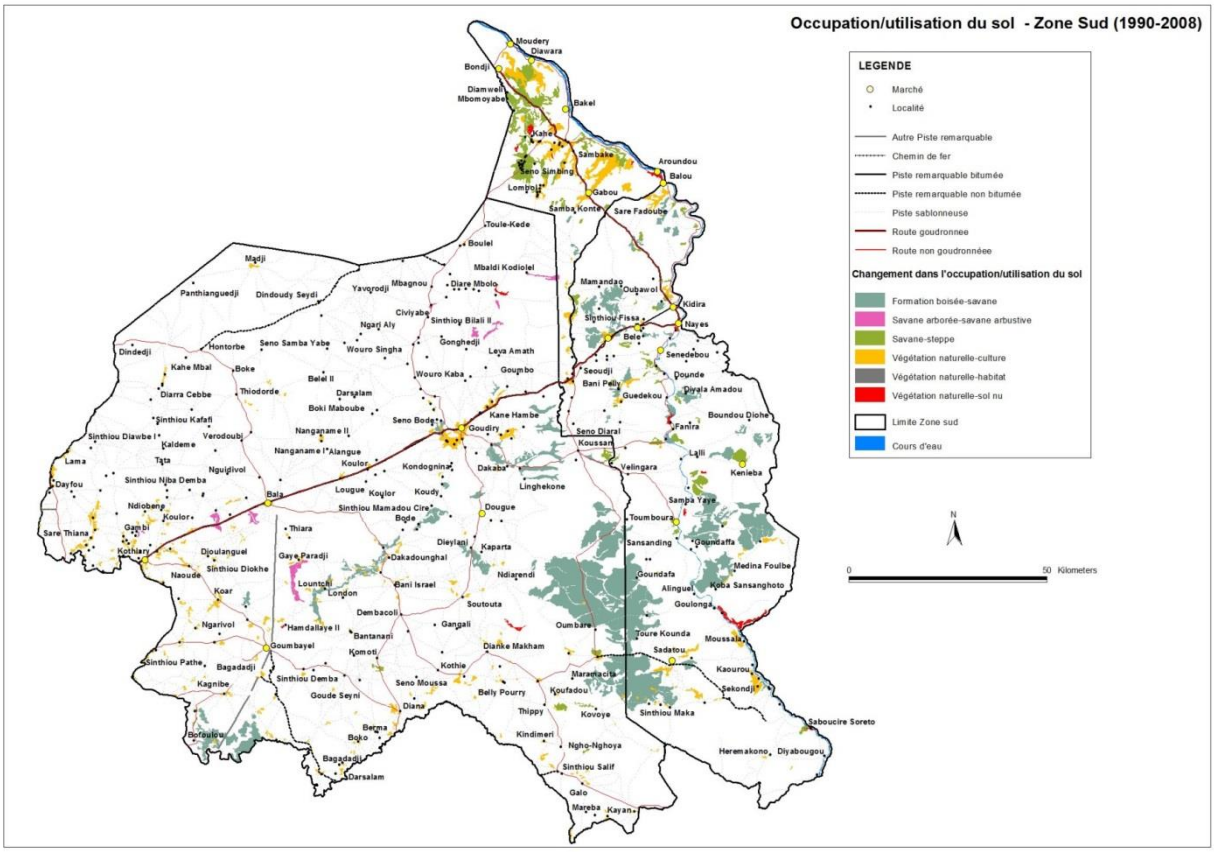
MAP 5: ANALYSIS OF MARKET ACCESSIBILITY IN THE STUDY ZONE



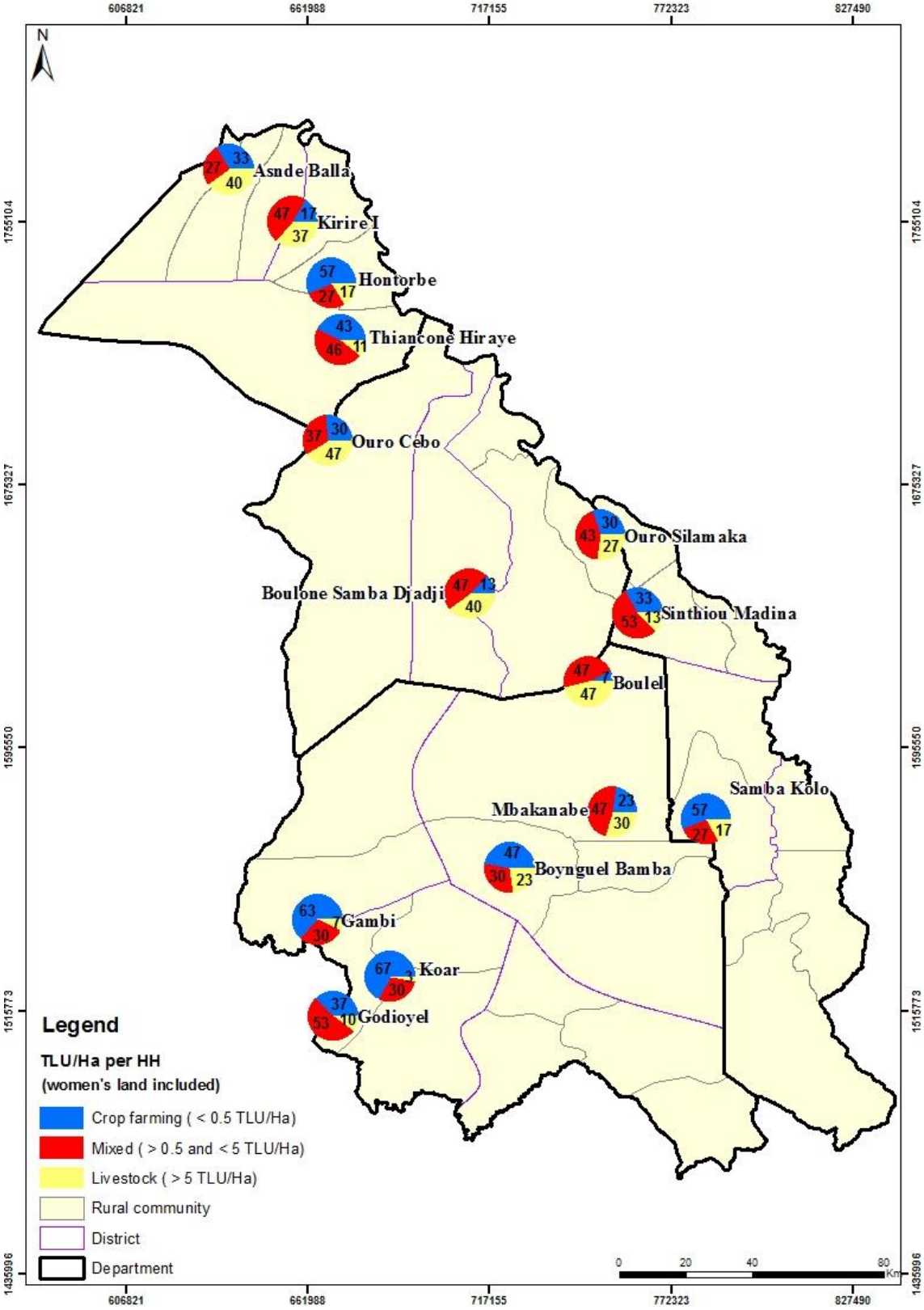
MAP 6: CHANGES IN LAND USE, NORTHERN SUB-ZONE



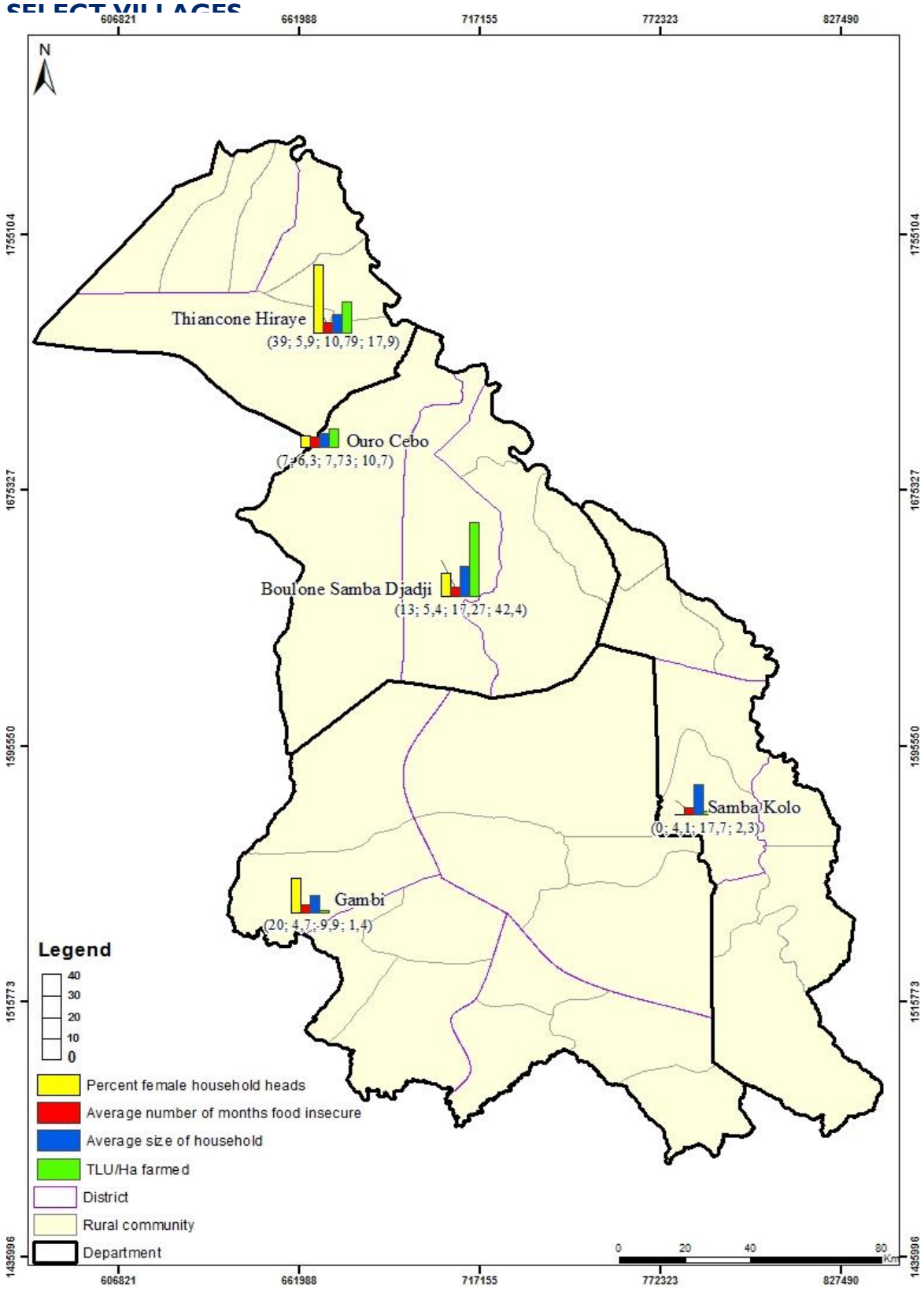
MAP 7: CHANGES IN LAND USE, SOUTHERN SUB-ZONE



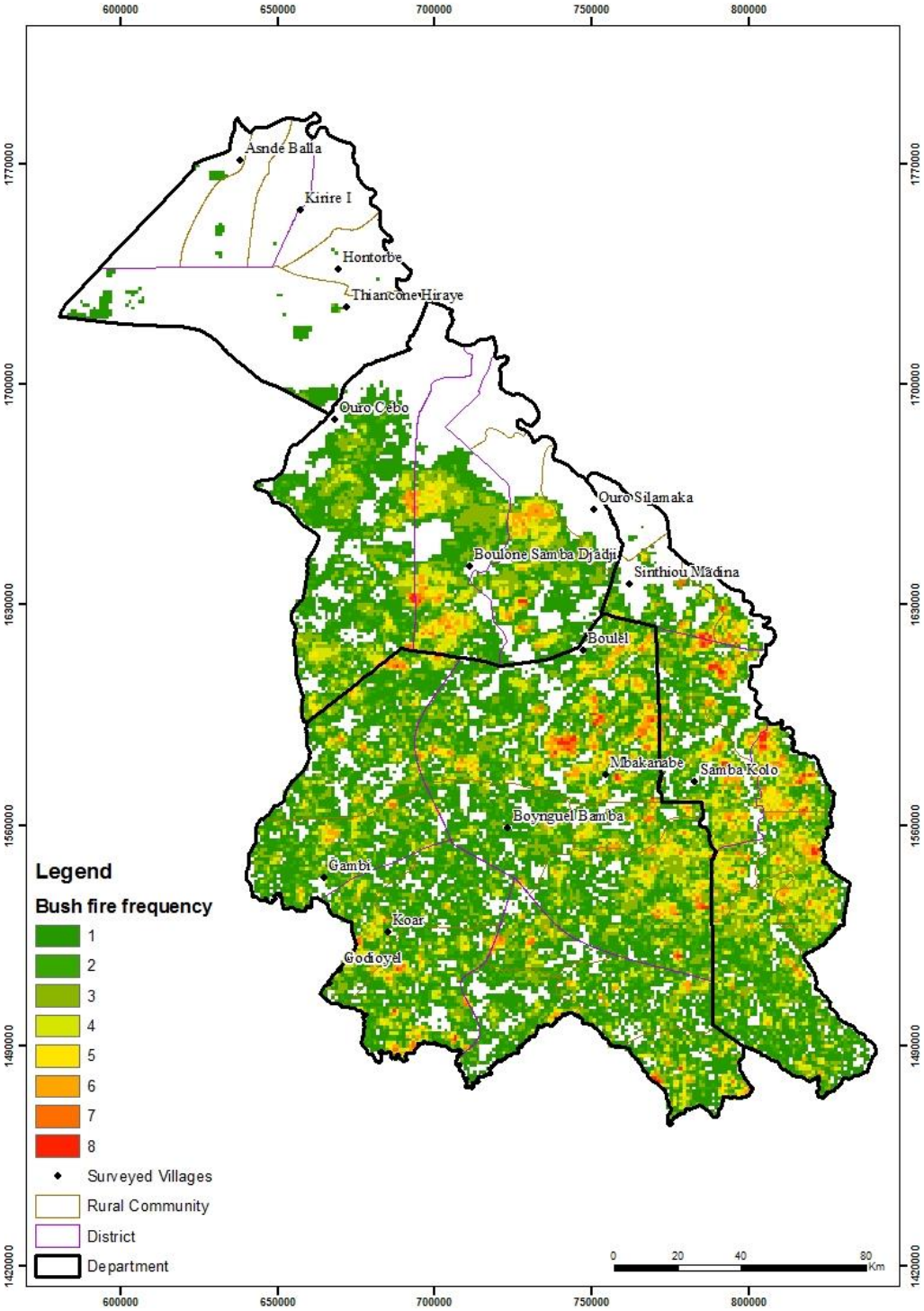
MAP 8: DISTRIBUTION OF STUDY LIVELIHOODS BY PERCENTAGE



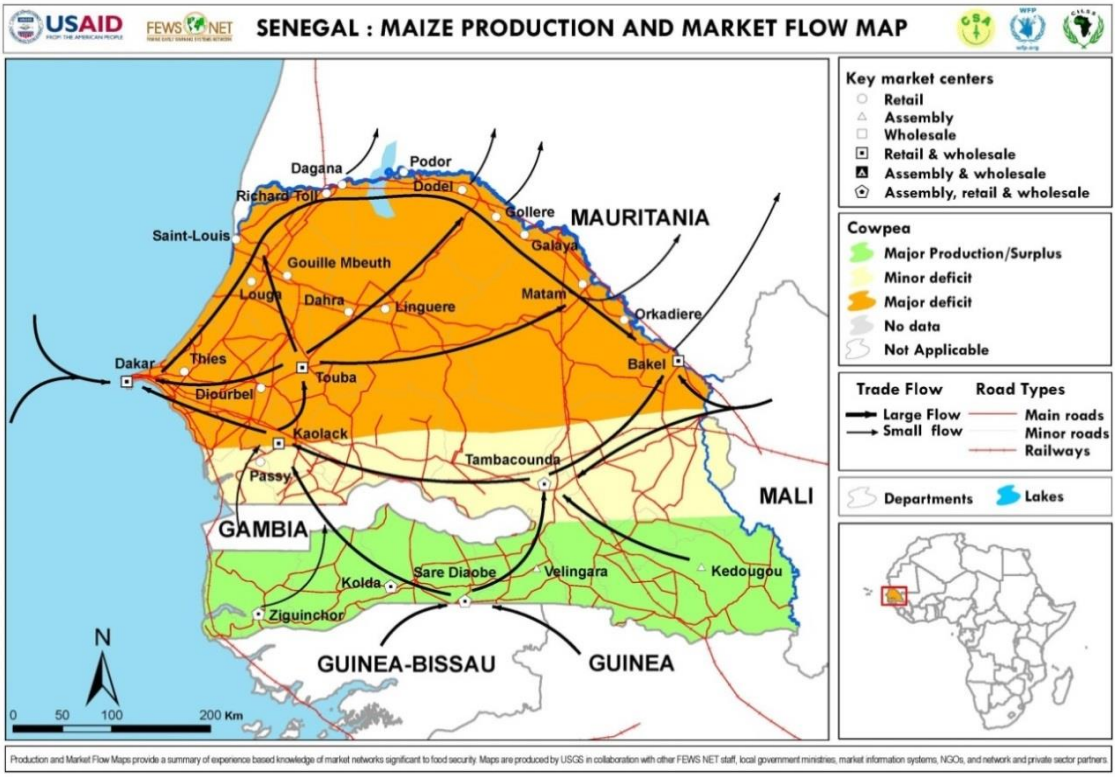
MAP 9: DIFFERENCES AMONG SURVEY VILLAGES: SELECT INDICATORS, SELECT VILLAGES

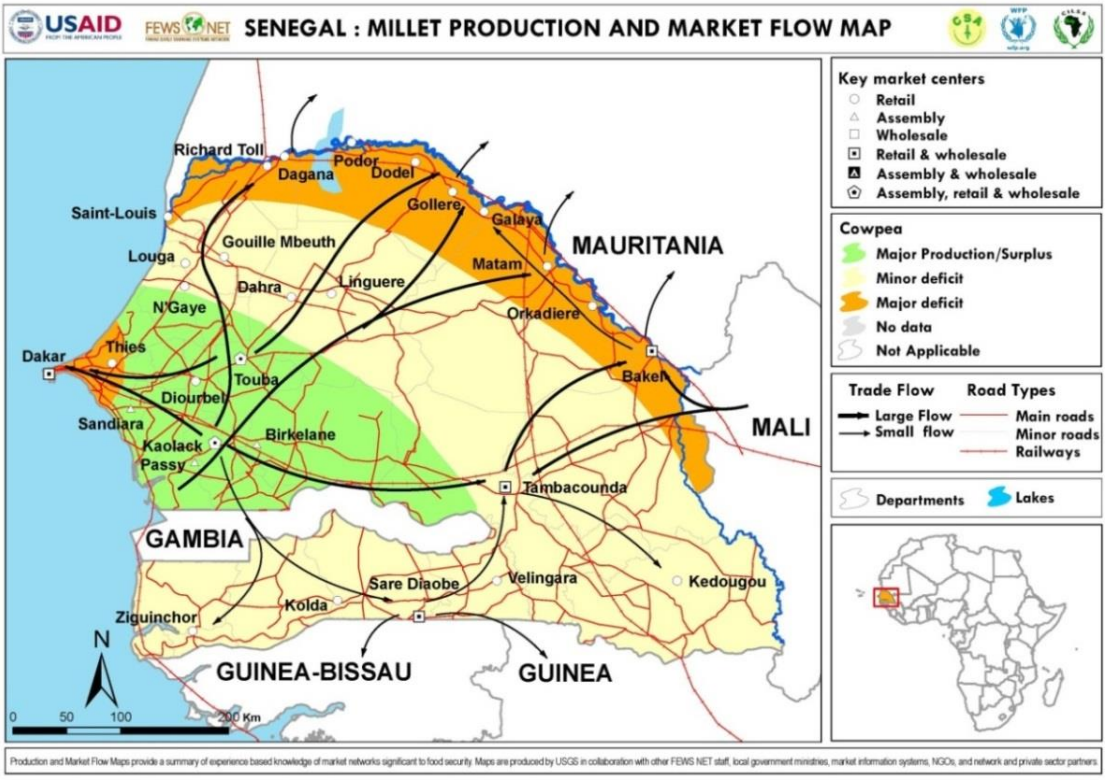


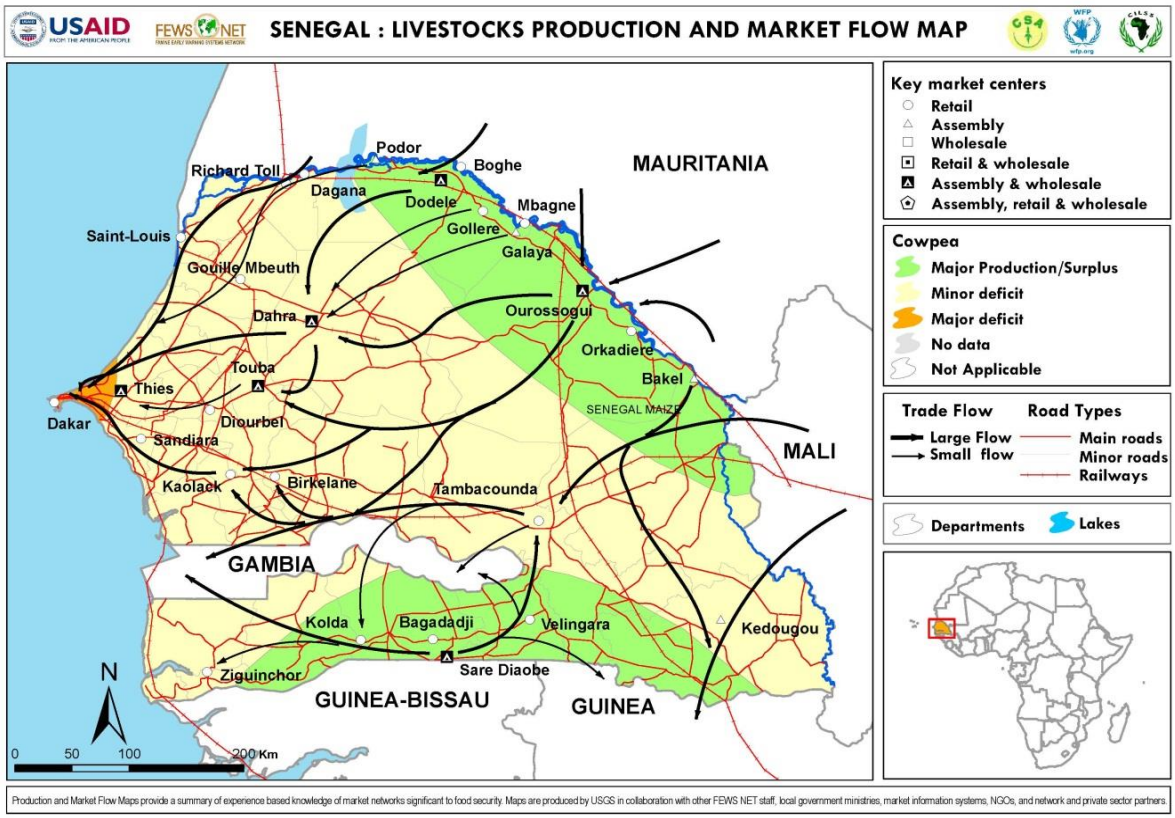
MAP 10: FREQUENCY OF FIRES IN THE TEN PAST YEARS *(October 2003 to June 2013) produced using maps of the areas burnt, produced annually by CSE using MODIS data.*

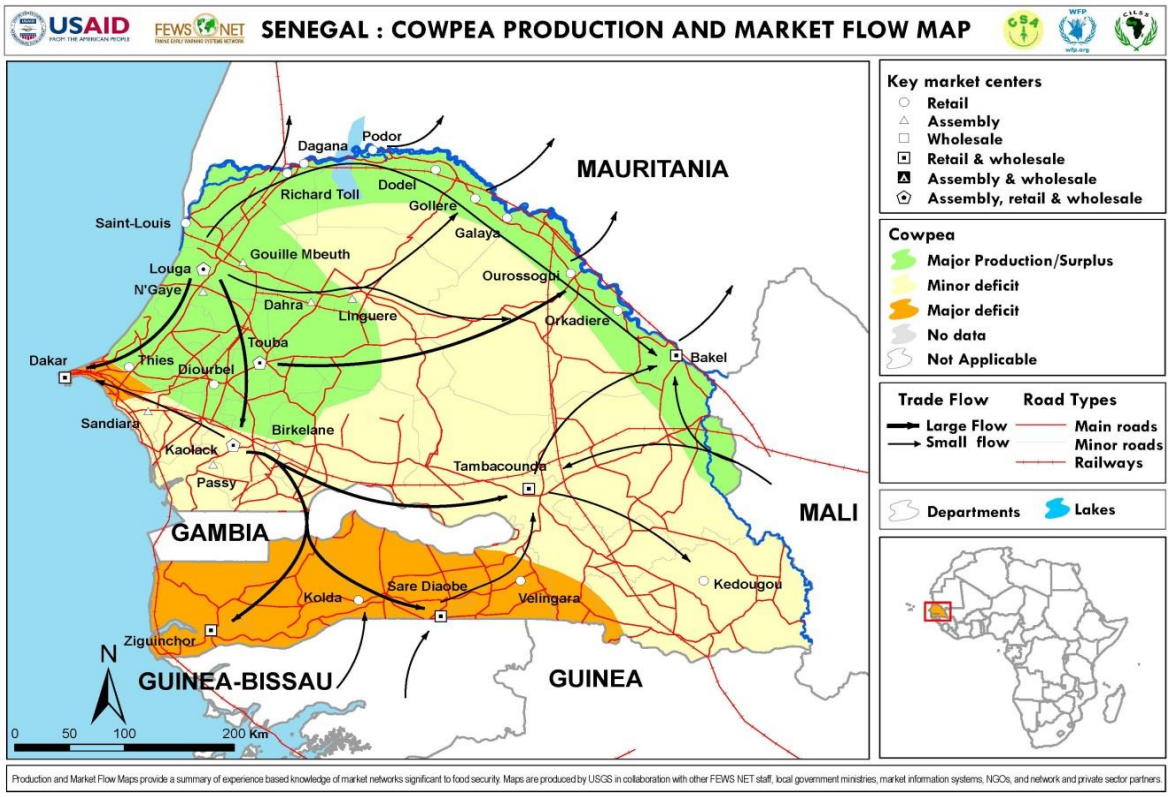


MAPS 11-14: USAID SENEGAL PRODUCTION AND FLOW MAPS






SENEGAL : LIVESTOCKS PRODUCTION AND MARKET FLOW MAP
Key market centers
Retail
Assembly
Wholesale
Retail & wholesale
Assembly & wholesale
Assembly, retail & wholesale
Cowpea
Major Production/Surplus
Minor deficit
Major deficit
No data
Not Applicable
Trade Flow
Large Flow
Small flow
Road Types
Main roads
Minor roads
Railways
Departments
Lakes
MAURITANIA
MALI
GAMBIA
GUINEA-BISSAU
GUINEA
Podor
Richard Toll
Boghe
Dagana
Dodele
Mbagne
Gollere
Galaya
Saint-Louis
Gouille Mbeuth
Dahra
Ourossogui
Orkadiere
Touba
Thies
Bakel
Dakar
Diourbel
Sandiara
Kaolack
Birkelane
Tambacounda
Kolda
Bagadadji
Velingara
Kedougou
Sare Diaobe
Ziguinchor
SENEGAL MAIZE
N
0 50 100 200 Km
Production and Market Flow Maps provide a summary of experience based knowledge of market networks significant to food security. Maps are produced by USGS in collaboration with other FEWS NET staff, local government ministries, market information systems, NGOs, and network and private sector partners.


SENEGAL : COWPEA PRODUCTION AND MARKET FLOW MAP
Key market centers
Retail
Assembly
Wholesale
Retail & wholesale
Assembly & wholesale
Assembly, retail & wholesale
Cowpea
Major Production/Surplus
Minor deficit
Major deficit
No data
Not Applicable
Trade Flow
Large Flow
Small flow
Road Types
Main roads
Minor roads
Railways
Departments
Lakes
MAURITANIA
MALI
GAMBIA
GUINEA-BISSAU
GUINEA
Dagana
Podor
Richard Toll
Dodel
Gollere
Galaya
Saint-Louis
Gouille Mbeuth
Louga
N'Gaye
Ourossogui
Dahra
Linguere
Orkadiere
Touba
Bakel
Dakar
Thies
Diourbel
Sandiara
Birkelane
Kaolack
Tambacounda
Passy
Kedougou
Kolda
Sare Diaobe
Velingara
Ziguinchor
N
0 50 100 200 Km
Production and Market Flow Maps provide a summary of experience based knowledge of market networks significant to food security. Maps are produced by USGS in collaboration with other FEWS NET staff, local government ministries, market information systems, NGOs, and network and private sector partners.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES N – P

SEPTEMBER 2014

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ARCC

African and Latin American Resilience to Climate Change Project

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ANNEX N. ÉVALUATION DE LA VULNERABILITE DU SENEGAL AU CHANGEMENT CLIMATIQUE ET ANALYSE DES OPTIONS

BUREAU D'ANALYSES MACRO-ECONOMIQUES

ETUDE ARCC

Évaluation de la vulnérabilité du Sénégal au changement climatique et analyse des options

REVUE BIBLIOGRAPHIQUE : VULNERABILITE ET MARCHES

AOUT 2013

EXECUTIVE SUMMARY

Vulnerability is generally defined as the probability of seeing one's situation or living conditions deteriorate, regardless of one's level of financial strength, in the face of a shock or hazardous event. This concept has been the subject of numerous approaches that differ according to their theoretical affiliation. As a result, several vulnerability models have been developed through research: ecological, economic, sociological, and "mixed." The vulnerability of rural households in Senegal is continually increasing, particularly in our region of study (Matam, Kanel, Bakel and Goudiry), due to several factors that are not necessarily related to climate change. The purpose of this research was to analyze market responses in the face of an increasingly precarious and unstable environment marked by climate change and the lack or absence of infrastructure. In order to do so, the analysis of relationships between the market and vulnerability must be systemic, integrating ecological, economic, and social dimensions. This approach, which shows a direct link between vulnerability and the market, is promoted in this document.

Relationships between the market and vulnerability are very complex. The market provides an opportunity to adapt to risks (ecological, economic, and social) but is also a factor in the vulnerability of households, production systems, and localities.

On the one hand, markets can be sources of revenue through the sale of agricultural products, livestock, dairy products, and harvested products. Markets can also be a source of food or input supplies for households or farms. They can serve as hubs of opportunity for localities if

- They are located near paved roads and large assembly or consumer markets;
- The market supply (food products and agricultural input) is of high quality, available in large quantities, diversified, and constant; and
- There is a high demand for food products (rice, millet, corn, sorghum, etc.).

On the other hand, markets can also be a source of vulnerability for localities, households, and production systems due to high demand in the face of limited supply (variable supply, price instability, etc.), frequency of markets (weekly), problems related to transport (road quality), low storage capacity (electricity problems), competition from imported products, and poor access to credit.

The specialization of production systems in food-producing cultures can constitute a source of household vulnerability because cereal production (based solely on rainfed agriculture) often fails to meet cereal needs.

The main factors in the vulnerability of grazing systems are accessibility and the availability of water and pasture resources. Access to these natural resources is often hindered by major developments in the area (repeated droughts, rising prices of livestock feed, bush fires, unseasonable rains, prolonged forage shortage, massive arrival of transhumants from other areas, etc.).

To summarize, a review of the literature shows that even if markets can be a source of vulnerability for agricultural production systems, there are ways in which they can lessen this vulnerability. Thus, even if the current configuration of markets accentuates the vulnerability of households, it creates a certain consensus in favor of the public regulation of markets and the implementation of commercial policies that aim to improve household access to food products or facilitate the flow of agricultural production.

RESUME

Au sens général, la vulnérabilité est définie comme la probabilité de voir sa situation ou ses conditions de vie se dégrader, quel que soit son niveau de richesse, face à un choc ou un aléa. Ce concept fait l'objet de plusieurs approches qui se distinguent de par leur appartenance théorique. Ainsi, plusieurs modèles de vulnérabilité sont développés par les recherches: écologiques, économiques, sociologiques et "*mixtes*". La vulnérabilité des ménages ruraux prend de plus en plus de l'ampleur, particulièrement dans notre zone d'étude (Matam, Kanel, Bakel et Goudiry), du fait de plusieurs facteurs qui ne sont pas forcement liés aux changements climatiques. L'objet de cette recherche était d'analyser les réponses des marchés face à un environnement de plus en plus précaire et instable caractérisé par le changement climatique, le manque ou l'absence d'infrastructures, etc.. Pour cela, l'analyse des relations entre le marché et la vulnérabilité doit être systémique en intégrant les dimensions écologiques, économiques et sociales. Ainsi; Cette approche, qui a la particularité d'afficher un lien organique entre la vulnérabilité et la marché, est mise en avant dans le présent document.

Les relations entre le marché et la vulnérabilité très sont complexes. Le marché peut être une opportunité pour s'adapter aux risques (écologique, économique et sociale) mais également facteur de vulnérabilité des ménages, systèmes de production ou localités.

D'une part, les marchés peuvent être sources de revenus par la vente de la production agricole, du bétail des produits laitiers et des produits de cueillette. Les marchés peuvent être également source d'alimentation ou de fourniture d'intrants pour les ménages ou exploitations agricoles. Ils peuvent constituer une opportunité pour les localités si:

- Elles sont situées prés des routes goudronnées et des grands marchés de regroupement et de consommation
- L'offre de marchés (produits alimentaires et intrants agricoles) est disponible en quantités et en qualité, diversifiée et constante
- La demande en produits alimentaires (riz, mil, mais, sorgho, etc.) est élevée

D'autre part, les marchés peuvent être aussi source de vulnérabilité des localités, des ménages et des systèmes de production du fait d'une forte demande face à une offre très limitées (variabilité de l'offre, instabilité des prix, etc.), de la fréquence des marchés (hebdomadaires), des difficultés liées au transport (qualité des routes), des faibles capacités de stockage (problèmes d'électricité), de la concurrence des produits importés et du faible accès au crédit.

La spécialisation des systèmes de production dans les cultures vivriers peut constituer une source de vulnérabilité des ménages dans la mesure où la production céréalière (uniquement basée sur une agriculture pluviale) ne permet pas souvent de couvrir les besoins céréaliers.

Les principaux facteurs de vulnérabilité des systèmes pastoraux sont l'accessibilité et la disponibilité des ressources en eau et en pâturage. L'accès à ces ressources naturelles est souvent entravé par les principaux événements intervenus dans la zone (sécheresses répétées, hausse des prix de l'aliment de bétail, feux de brousse, pluies contre saison, pannes prolongées du forage, arrivée massive de transhumants en provenance d'autres zones, etc.).

En somme, l'analyse bibliographique montre que même si le marché peut être source de vulnérabilité des systèmes de production agricoles, ceux ci disposent de marges de manœuvre pour atténuer cette vulnérabilité. Ainsi, même si la configuration actuelle des marchés peut accentuer la vulnérabilité des ménages, elle crée un certain consensus en faveur d'une régulation publique des marchés et d'une mise en place politiques commerciales visant à améliorer l'accès des ménages aux produits alimentaires ou à faciliter l'écoulement des productions agricoles.

INTRODUCTION

Depuis environ deux décennies, la vulnérabilité s'est révélée comme un concept incontournable pour appréhender les conditions de vie des agriculteurs et les stratégies de survie développées par ceux-ci pour faire face aux risques et incertitudes des milieux qu'ils exploitent. En effet, de nombreuses contributions abordent cette question de la vulnérabilité sous des angles variés (écologiques, économiques, sociétales,…). Des projets de recherches étendues sur des terrains contrastés alimentent la réflexion autour de cette notion. Cette pluralité des recherches débouchent sur des approches qui permettent de re-questionner la vulnérabilité dans le contexte des agricultures de la zone de Matam, Kanel, Bakel et Goudiry**.**

Ainsi, il est utile de circonscrire ce à quoi renvoie la vulnérabilité. « *Au sens général, la vulnérabilité est définie comme la prédisposition d'un système à souffrir d'un choc ou d'un stress externe provoqué par des aléas climatiques, des tremblements de terre ou des éruptions volcaniques* » (Touré et al, 2010). Cette définition donnant un sens écologique au terme montre que son utilisation était d'abord réservée à ce domaine de recherche avant d'être étendue à d'autres sphères, notamment les sciences sociales.

Ceci nous pousse à regarder ces autres acceptions du paradigme. Ainsi, la vulnérabilité est définie par "*conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards*" (UN/ISDR, 2004). Par ailleurs, elle est aussi et surtout située depuis un moment par rapport au changement climatique renvoyant au "*degré selon lequel un système est susceptible, ou se révèle incapable, de faire face aux effets néfastes des changements climatiques, notamment à la variabilité du climat et aux évènements climatiques extrêmes. La vulnérabilité dépend du caractère, de l'importance et du taux de variation climatique auxquels un système est exposé, de sa sensibilité et de sa capacité d'adaptation*" (CARE, 2010). Cette définition renvoie à trois indicateurs de la vulnérabilité à savoir la sensibilité, la capacité d'adaptation et l'exposition. La sensibilité est le degré selon lequel une communauté est affectée par des stress climatiques et cela dépend des moyens d'existence et du système de production. La capacité d'adaptation s'entrevoie à travers les stratégies d'adaptation mises en œuvre par les socio-systèmes face à des dommages potentiels. Lesquelles stratégies d'adaptation ne sont pas exclusives les unes des autres, elles sont toujours combinées entre elles, de manières à accroitre leurs effets et impacts sur les systèmes de production. L'exposition aux variations climatiques est en grande partie une question de localisation géographique. À cet effet, les données statistiques en 2012 sur la vulnérabilité au Sénégal montrent que les régions de Matam et de Tambacounda présentent les populations les plus vulnérables à l'approche de l'hivernage. Cette vulnérabilité s'accentue plus dans les systèmes de production vivriers essentiellement dépendant de la production de céréales et des produits de systèmes d'élevage extensifs complètement exposés aux aléas et où 100% des familles sont très vulnérables (CILSS, 2000).

Au Sénégal, dans les régions de Matam et de Tambacounda, les activités économiques dominantes restent l'agriculture et l'élevage (SES Matam 2010 et SES Tambacounda 2009). Elles occupent la majorité de la population active et épousent des formes diversifiées à savoir l'agriculture pluviale, de décrue et irriguée alors que l'élevage est généralement extensif (UNDP, 2013)

Les systèmes de production présents dans les zones de Matam et de Tambacounda peuvent être classés en deux grandes catégories : les systèmes de production agricoles qui se déclinent en trois types sur la base de la culture dominante (SP céréaliers, de rente, et mixtes) et les systèmes de production pastoraux (système d'élevage transhumant, système d'élevage agro-pastoral).

L'agriculture constitue la première activité pratiquée par les populations de la région de Matam (SES Matam, 2010). Elle mobilise plus de 70% de la population et contribue pour 40 % à la constitution de la part du secteur primaire dans la formation du PIB régional (UNDP, 2013). Les principales spéculations

sont le mil, le riz, le sorgho, le mais, l'arachide et le niébé. L'importance du cheptel dans la région se ressent à travers son nombre et sa diversité (bovins, ovins, caprins, équins, asins et volailles). Malgré les campagnes de vaccination menées dans cette zone, la pasteurellose, le botulisme, la clavelée semblent endémiques (SES Matam 2010).

Dans la région de Tambacounda (zone agro-sylvo-pastorale), l'agriculture et l'élevage sont les premiers piliers de l'économie. L'importance relative de l'élevage par rapport à l'agriculture dépend des groupes socioéconomiques et de l'appartenance ethnique (Peulhs, Mandingues, Soninkés, Wolofs, Bambaras) dans une certaine mesure (Save the Children et Commissions Européenne, 2011). Les céréales (mil, sorgho et maïs) sont les principales cultures vivrières. L'arachide et le coton sont les principales cultures de rente. Le cheptel est constitué de bovins, ovins, caprins, équins, asins et volailles. L'accès aux intrants agricoles constituent une contrainte majeure des populations de ces deux régions. Les marchés jouent un rôle important dans ces deux régions. Les agriculteurs vendent leur production après les récoltes. Ils achètent également de la nourriture sur le marché, spécifiquement le riz, durant la saison sèche jusqu'à la prochaine récolte. La vente des produits maraichers, du bois de chauffe, du charbon, du pain de singe, du bétail et de la force de travail constituent de véritables sources de revenus durant la contre-saison (Save the Children et Commissions Européenne, 2011).

L'agriculture et l'élevage reposent sur une organisation socio-économique familiale, cette structuration socio-familiale est souvent considérée comme « *le mode de mise en valeur agricole le plus résilient grâce aux mécanismes de gestion du risque développé depuis des générations par les agriculteurs et leurs familles* » (AVSF, 2012). Ainsi, l'adaptation aux aléas et la gestion du risque semblent intrinsèques aux leviers sur lesquels ces exploitations familiales se basent pour faire à l'incertitude inhérent au milieu. Ces leviers des systèmes agraires traditionnels sont l'auto-assurance (épargne), la complémentarité entre spéculations et espaces utilisés au sein des exploitations et/ou des communautés, la mobilité et les filets de sécurité sociale comme l'entraide. Toutefois, ces stratégies reposant à la fois sur des choix technico-économiques et une organisation sociale sont actuellement de plus en plus affaiblies dans un contexte de changement climatique. Celui-ci se traduit localement par la modification des conditions de production (retard arrivée pluie, pauses pluviométriques plus importantes, grande variabilité spatio-temporelle de la pluie et de la température, changement de la structure des troupeaux, changement des zones de pâturage, des dates de déplacement…). L'impact de cette variabilité climatique serait d'autant plus fort que les agricultures familiales subissent aussi d'autres mutations de leur environnement : i) dégradation de la fertilité, ii) déforestation et érosion de la biodiversité, iii) insertion à l'économie de marché et libéralisation, avec ses exigences de compétitivité, iv) position défavorisée pour l'accès aux ressources (eau, foncier notamment), mais également des problèmes de financement. Les risques dans leur globalité impactent négativement les moyens d'existences des exploitations familiales en en affectant le capital et les ressources sociales ce qui exposerait davantage les catégories les plus sensibles, à savoir les femmes et les enfants, à la vulnérabilité des populations sensibles. C'est pourquoi l'identification et le développement de nouvelles opportunités sont impératifs et doivent surtout insister sur la durabilité (moyen et long terme) des processus de production des chaînes de valeur (céréales, bétail, lait, viande, cultures irriguées).

Ainsi, le marché peut être un des mécanismes développés pour faire face à la vulnérabilité. Il est généralement admis que la vulnérabilité ou non des systèmes de production agricoles et/ou pastorales est intimement lié au marché c'est-à-dire aux modalités d'accès physique des systèmes au marché, au niveau et aux fluctuations des prix sur les marchés de proximité, ainsi qu'au niveau d'approvisionnement des marchés en quantité, en diversité et dans le temps. Le marché est donc particulièrement indispensable surtout pour les ménages les plus vulnérables (DABAT et al., 2012).

Les disciplines (économie, sociologie,) et approches sur le concept de marché s'intéressent aussi bien aux marchés physiques ou commerciaux qu'aux marchés géographiques. Ainsi, les marchés sont généralement classés selon la nature produits (marché de biens ou services), la taille (marché de grande

consommation ou de niche), la dimension géographique (qui peut s'étendre au delà des frontières nationales), la structure (monopole, oligopole, monopsone, concurrence, etc.), la filière (céréales, lait, viande, bétail, etc.). Les spécificités des marchés localisés dans les régions de Tambacounda et de Matam feront l'objet d'une attention particulière. Ainsi, l'accent sera mis aussi sur les produits comme les céréales, le lait et les produits laitiers, la viande, le bétail, etc.

Il convient de noter que le marché sera analysé par rapport à la vulnérabilité des ménages en mettant l'accent sur l'offre, la demande, les prix, les circuits de commercialisation, l'impact du marché sur les revenus et l'alimentation des ménages et les facteurs exogènes qui influent sur le marché (politique commerciale, localités, etc.).Cette revue bibliographique orientée sur la vulnérabilité par rapport au marché est structurée en trois parties. Une première partie concerne un survol des modèles de vulnérabilité qui affiche un lien organique entre la vulnérabilité et le marché . Dans la deuxième partie nous essayerons de développement les points de vue qui voient le marché comme une opportunité face à des risques. La troisième partie sera consacrée aux analyses des liens entre marché et vulnérabilité.

DES MODELES DE VULNERABILITE

La contribution scientifique de Sylvia Becerra (2012) à travers une étude des notions de vulnérabilité, risques et environnement oriente les lectures, fournit des éléments de circonscription intéressants de la vulnérabilité et dresse l'évolution du paradigme. Cette étude est réalisée dans le cadre d'un projet de recherche axé spécialement sur la vulnérabilité sociétale dans le Sahel, ces recherches capitalisent une banque d'études de cas qui seront très utiles pour contextualiser notre présente étude. D'autres points de vue alimentent cette synthèse, nous en citons quelques-uns: Cardona (1999); Birkmann (2006), Wisner et al. (2004), Turner et al.(2003) , Ancey et al., (2009).

La vulnérabilité d'un point de vue systémique

En Amérique latine un réseau scientifique appelé la RED (Réseau en sciences sociales pour la prévention des désastres.), a été créé à partir de l'idée que les catastrophes ne sont pas « naturelles » (Maskrey, 1993) mais plutôt le résultat de conditions socioéconomiques vulnérables (Blaickie et al., 1996). La RED considère ainsi la vulnérabilité comme une construction sociale ; pour la définir, elle prend en compte à côté des aspects physiques et matériels, des dimensions sociales comme la fragilité de la cellule familiale, l'accès à la propriété ou au crédit, les discriminations politiques ou sociales, l'absence d'occasion d'éducation, etc. (Cardona, 1999). Cette acception de la vulnérabilité permet d'agir sur des leviers autres que ceux relatifs à la variabilité du climat. De ce fait, dans cette étude, nous prêterons attention aux dimensions prises en compte par le point de vue systémique.

La vulnérabilité sociale, facteur de marginalité économique

Cannon et al. (2003) analysent par exemple la vulnérabilité sociale comme l'ensemble de caractéristiques initiales d'une personne ou d'un groupe (santé mentale et physique, biens de subsistance, protection sociale, capital social (réseaux), capacité d'auto-protection, etc.). Pour Wisner et al. (2004), ces caractéristiques influencent à la fois l'anticipation, l'aptitude à faire face à un aléa naturel ou environnemental tout comme la capacité à se remettre de ses impacts (Wisner et al., 2004). Cette manière de considérer la vulnérabilité peut être facilement reliée à la précédente dans la mesure où elle intègre les ressources sociales et économiques dont doivent disposer les socio-systèmes pour faire face à un environnement incertain et à risque. De ce point de vue, la vulnérabilité doit être analysée d'abord, comme un processus évoluant **sur trois échelles**, piliers du développement durable : **sociale, économique et environnementale**. Ensuite, l'analyse intègre l'estimation des défaillances et des impacts des catastrophes dans le passé pour observer la vulnérabilité présente d'un élément, individu,

groupe ou société (dans ces trois domaines) définie à la fois comme la susceptibilité physique, la fragilité socio-économique et le manque de résilience (Birkmann, 2006). Le cadre conceptuel est donc fortement ancré sur la problématique du développement durable et donne une place majeure au contexte environnemental dont les sociétés dépendent (Turner et al., 2003).
Becerra (2012) synthétise les approches et échelles d'analyse de la vulnérabilité proposée par Birkman et Wisner (2006) que nous trouvons intéressant à reprendre ici :

(1) la vulnérabilité est la caractéristique intrinsèque d'un élément ou d'un système (Cardona, 2004) ;

(2) elle rend compte de la probabilité de subir une blessure voire la mort, la détérioration voire la perte des biens de subsistance (Wisner et al. 2004) ;

(3) la vulnérabilité a une face externe -exposition au **danger**- et une face interne -difficultés à faire face ou à récupérer suite à un choc (Bohle, 2001 ; Wisner, 2002) ;

(4) enfin, c'est un processus pluriel et multiscalaire : il englobe à la fois la **susceptibilité**, les **capacités à faire face** mais aussi l'**adaptation** (Turner et al., 2003) et l'exposition physique à différentes échelles spatiotemporelles et dans différents domaines (société, environnement, économie). Comme le souligne Warner (2007) la vulnérabilité sociale n'est finalement qu'un des aspects de la vulnérabilité qu'une société peut avoir face à des stress ou chocs parmi lesquels on trouve les aléas environnementaux. Le terme désigne ainsi les impacts subis du fait de l'incapacité d'une société à les réduire en raison des caractéristiques inhérentes aux interactions sociales (rapports de pouvoir), institutions et valeurs culturelles de cette même société. Cette conception de la vulnérabilité nous permettra de considérer dans cette étude, toutes les faiblesses sociales et économiques du groupe social qui accentueraient l'acuité des chocs climatiques.

Sécurisation d'un mode vie face à la vulnérabilité

Un modèle de vulnérabilité adapté aux systèmes pastoraux peut être cité ici et mobilisé dans cette étude pour analyser les déterminants de la vulnérabilité et ceux de l'adaptabilité des agropasteurs. Ce modèle capitalise les apports théoriques d'Amartya Sen (endowment / entitlement) et Jeremy Swift. Les endowments correspondant à la « **disponibilité des ressources** » et les entitlement correspondant aux **capacités à mobiliser des ressources**. Le modèle se centre sur les capacités à mobiliser les stocks, les recours et les stratégies. Il est admis pour cette approche que les chefs d'exploitation s'appuient tout ou partie de l'année sur leurs stocks en troupeaux, en main d'œuvre familiale, en épargne, en matériel, en réserves alimentaires, pour exercer leurs activités. Les stratégies regroupent les activités productives génératrices de revenus ou garantissant l'entretien et la reproduction des stocks (de la transhumance par exemple, à la modification du régime alimentaire). Les recours sont les pratiques classées comme non « productives » faisant appel à l'entraide, au crédit, au positionnement dans les associations locales (Ancey, 2009).

Ce modèle de vulnérabilité a été mis à l'épreuve par des enquêtes qui se sont servies des chocs récents vécus par les populations et il s'est révélé pertinent pour mesurer les stratégies de sécurisation mises en pratiques par les agropasteurs pour maintenir leur système de production et leur mode de vie. Les indicateurs développés par ce modèle sont répartis en deux sous-groupes : des *endowments* (ressources disponibles) que sont la pluviométrie, la production céréalière, le disponible fourrager ; les ressources en eau ; et des *entitlements* (aptitudes à mobiliser) qui prennent en charge les indicateurs de marché (termes de l'échange céréales/ bétail, ampleur et structure de l'offre), et les changements des stratégies : (gestion du troupeau, types de travaux, migrations).

Les modèles ou acception de la vulnérabilité que nous avons choisis délibérément de mobiliser ici permettent de relier l'intégration de systèmes de production agropastoraux des régions de Matam et Tambacounda aux échanges marchands.
Nous pensons que l'analyse des relations entre la vulnérabilité et le marché doit être systémique, en intégrant plusieurs dimensions : écologique, sociale et économique. Ainsi, dans l'analyse de la vulnérabilité par rapport au marché, il est utile voir l'impact du marché sur la vulnérabilité des ménages d'un point de vue systémique en intégrant ces trois dimensions.

Vulnérabilité et marché : un lien de fait ?

La définition de vulnérabilité d'un point de vue systémique énoncée précédemment affichent un lien organique entre la vulnérabilité et le marché. La réalité des marchés est extrêmement variée. De nombreuses recherches ont abordé le marché sous différents angles (économie, sociologie économique etc.). Le marché est défini dans la théorie économique comme le lieu sur lequel se rencontrent l'offre et la demande pour un bien ou un service spécifique. Les économistes néoclassiques conçoivent le marché comme un mécanisme autorégulateur, permettant l'émergence de prix équilibrant les offres et demandes des biens et services présents sur le marché. "Pour la sociologie, la démarche la plus commune est de considérer le marché comme une structure sociale". La sociologie économique contemporaine s'intéresse à la construction sociale des marchés c'est-à-dire l'origine de cette structure sociale (Steiner; 2005). Ainsi, le marché repose sur deux types de relations sociales : l'échange et la concurrence (François, 2008).

Si le marché est entendu dans le sens de Grossetti comme l'ensemble des relations d'échanges entre acteurs ou réseaux d'acteurs. Il recouvre un ensemble de règles instituant les échanges économiques, faisant qu'il existe autant de marchés que de produits ou autant de marchés que de rencontres d'offre et de demande (Grossetti et Bès, 2003). Le marché correspond ainsi à une réalité économique virtuelle comme la rencontre abstraite d'une offre et d'une demande, et plus largement une rencontre d'une chaine d'acteurs et de réseaux d'acteurs.

Il n'en demeure pas moins que le lieu de rencontre physique où des individus proposent leur production et où d'autres viennent s'approvisionner reste une compréhension communément partagée. Ce marché, lieu physique, représente une réalité concrète dans les territoires du Sénégal Oriental où la diversité des produits créent des opportunités d'échanges entre acteurs économiques, comme les capacités des agro-éleveurs à se positionner sur ces marchés peuvent être déterminantes pour leur permettre d'en tirer profit (Diao-Camara, 2013).

Il est généralement admis que la vulnérabilité ou non des systèmes de production agricoles et/ou pastorales est intimement lié à l'accès au marché. Le marché est donc indispensable pour les localités, les systèmes de production et les ménages les plus vulnérables (DABAT et al., 2012). On pourrait ainsi s'attendre à une insertion croissante des agricultures familiales à des marchés de plus en plus concurrentiels et par conséquent à une monétarisation des échanges. Cette recherche est l'occasion de connaître les réponses des marchés face à ce nouvel environnement de plus en plus précaire et instable. Sur ces marchés, les mêmes ménages peuvent être à la fois acheteurs ou vendeurs, selon les périodes et les produits, et ces marchés peuvent diminuer ou accroître la vulnérabilité des ménages (DABAT et al., 2012) ; d'où la nécessité de considérer le marché comme une opportunité pour s'adapter aux risques mais également comme facteur de vulnérabilité .

LE MARCHE, OPPORTUNITE FACE AUX RISQUES

Les éléments de caractérisation des marchés sont leur localisation, la qualité de leurs voies d'accès, leur organisation et en particulier leurs fréquences d'ouverture, leur niveau de fréquentation, la nature et le

volume des produits qui sont échangés, leur place dans les circuits de commercialisation, leur connexion avec les autres marchés, les dispositifs d'information renseignant les acteurs et les pratiques des acteurs sur les marchés.

De ce point de vue, le marché physique peut constituer une opportunité pour s'adapter aux risques parce qu'il peut être une source de revenus et une source d'alimentation pour les exploitations agricoles.

Le marché: source de revenus pour les systèmes de production

Pour certaines économies familiales le marché pourrait faciliter l'accès à des revenus (vente de la production agricole, du bétail et des produits de cueillette) et pour l'achat de produits alimentaires (DABAT et al. 2012, p.68). Pour ce faire, le marché peut présenter plusieurs opportunités pour les systèmes de production agricoles et pastoraux de la zone d'étude parce qu'il permet d'avoir un revenu immédiat, de favoriser le développement de nouvelles activités mais aussi de diversifier les sources de revenus, de permettre la possibilité de fractionner les revenus dans le temps, de partager le risque sur plusieurs produits et de s'affranchir partiellement de la pression des collecteurs. La plupart des échanges sont monétaires, même si d'autres formes de transactions ne sont pas négligeables : paiement en nature ou troc. Il représente une opportunité de vendre les surplus de produits vivriers mais aussi de diversifier la production et d'obtenir des revenus à partir d'un plus grand nombre de produits. Par exemple dans la région de Matam, les fruits de Balanites *aegyptiaca* et de Zizyphus *Mauritiana* constituent l'essentiel des produits de cueillette. Leur commercialisation contribue d'une manière substantielle à l'augmentation des revenus des populations locales (SES Matam, 2010).

Le marché: source d'alimentation pour les exploitations agricoles

Le marché est la principale source d'approvisionnement en produits alimentaires des ménages. Les ménages utilisent largement le marché pour satisfaire leur survie alimentaire ou pour diversifier leur ration alimentaire (DABAT et al., 2012, p.9). Par l'ajustement aux besoins alimentaires, la diversification de l'alimentation, la flexibilité de la gestion de l'approvisionnement en céréales (autoconsommation ou marché, limitation des stocks), le marché constitue également une source d'alimentation des exploitations agricoles et pastorales. En effet, le marché est la principale source d'approvisionnement en produits alimentaires des ménages. Quelle que soit leur catégorie sociale, les ménages utilisent largement le marché pour satisfaire leurs besoins alimentaires ou pour diversifier leur ration alimentaire. Le marché joue un rôle important dans l'alimentation des ménages seulement quand les produits atteignent les marchés de proximité et sont disponibles à l'achat et à la vente. La pratique de la vente à crédit par les détaillants de céréales permet aux ménages vulnérables d'élargir et de renforcer leur accès aux aliments en période de crise (CILSS, la FAO, FEWS NET, et le PAM, 2010).

L'offre de marché disponible, diversifiée et constante

Le marché peut constituer une opportunité si l'offre est disponible en quantités et en qualité, diversifiée et constante. Ainsi, pour une meilleure analyse de la structuration de l'offre pour cette étude, il convient de mettre l'accent sur les différents types de marchés existants, les circuits de commercialisation (acteurs, produits commercialisés), l'impact des politiques publiques et la formation des prix.

Les types de marché

Il est difficile de faire une typologie des marchés car certains d'entre eux changent de catégorie selon les périodes de l'année. Néanmoins, plusieurs études ont essayé de faire une typologie des différents marchés en insistant sur leur taille, les produits vendus, etc. Dans les systèmes d'élevage, CESARO et al.

(2010) ont retenu, quatre types de marché : (1) le campement ou le forage, (2) le *loumo* (marché hebdomadaire), qui se tient une fois par semaine, polarise un groupe de villages où il assure la distribution finale des biens de consommation et la collecte primaire des productions agricoles, (3) les marchés urbains périphériques et les grands marchés de regroupement comme Dahra, (4) les grands marchés de consommation (Dakar, Thiès, Touba). DABAT et al. (2012) distinguent également quatre types de marché : les marchés porte à porte, les marchés bord champs, les bourses céréalières, les marchés des institutions (impliquent les structures étatiques, ONG, Projet, …) et les marchés physiques (installés par les collectivités locales). Pour les produits forestiers non ligneux, Sène et al. (2004) distinguent trois principales catégories de marchés : les marchés primaires, localisés dans les zones de production, qui sont souvent des marchés hebdomadaires de seconde importance; les marchés de groupage qui sont, des marchés hebdomadaires ou certains marchés de gros villages, où sont acheminés les plupart des produits pour leur commercialisation; les marchés urbains de distribution constitués de marchés de gros/spécialisés (syndicat), les marchés de détail et les marchés intermédiaires/spécialisés où les acteurs évitent souvent les produits saisonniers périssables.

En résumé, nous pouvons retenir trois principaux types de marché comme le relève le CILSS (2010) : le marché hebdomadaire rural ou *loumo*, le marché de regroupement et le marché de consommation. D'abord, le marché rural hebdomadaire est à la fois un marché de production et de consommation. Pendant la période des récoltes, la principale fonction du marché rural est la collecte des céréales et des produits de rente, ainsi que la vente des produits importés ou manufacturés aux ménages. Pendant la période de soudure, le *loumo* change de vocation et devient essentiellement une source d'approvisionnement des ménages en céréales (CILSS, 2010). Ensuite, les marchés de regroupement constituent l'interface entre les marchés hebdomadaires ruraux, les marchés urbains de consommation et le marché international. Les marchés de regroupement disposent généralement d'un bon accès routier et de magasins de stockage. Ils sont fréquentés aussi bien par des vendeurs que sont les producteurs ou collecteurs que par des acheteurs (expéditeurs vers d'autres zones) que sont les grossistes. Ce sont des marchés qui peuvent se spécialiser par filière (Dahra : Bétail, Richard Toll : riz, …) dont les volumes importants d'échange se font entre quelques grossistes. Au niveau de ces deux types de marchés, les commerçants sont très mobiles et ils constituent les relais entre louma et marché de groupement. Enfin, les marchés urbains de consommation satisfont la demande des zones urbaines par les apports des marchés de regroupement ou du port. L'offre et la demande y sont très diversifiées et on y rencontre toutes les catégories d'acteurs des chaines de valeur (du grossiste au détaillant). Ce sont des marchés permanents où d'importants volumes de transactions se produisent quotidiennement.

Tableau n°1 : Fonctions et caractéristiques des marchés du bassin ouest

Type de marché	Fonction	Caractéristiques	Marchés des Zones d'étude
Marchés ruraux de consommation (louma)	Collecte (récolte) Consommation (soudure)	Fréquence hebdomadaire, présence du commerce ambulant Peu de commerçants, demande faible, faible qualité des produits	Loumas de Nabadji Civol et Agname Thiodèye (Matam) Loumas de Bondji et Doundé (Kanel) Loumas Balla et Kothiari (Goudiry) Gabou (Bakel)
Regroupement	Commerce en gros	Fréquence hebdomadaire, spécialisation des marchés par filière	Ourosogui, Kidira, Goudiry, Bakel
Marchés urbains de consommation	Consommation (toute l'année)	Volumes importants, offre diversifiée	Tambacounda

Source : CILSS, 2010

Dans les zones de Matam et Tambacounda, on y rencontre ces différents types de marché avec un dynamisme plus ou moins soutenu selon les localités. Les principaux produits commercialisés sont très variés: les céréales, le bétail sur pieds, les produits forestiers non ligneux (PFNL) qui sont des produits de cueillettes (pain de singe, karité, jujube, etc.), les sous-produits de l'élevage (lait cru, lait caillé babeurre, huile de beurre, œufs, etc.), les sous-produits de l'agriculture (fanes et tourteaux d'arachide, etc.). En fonction de ces zones et de ces produits commercialisés, deux circuits sont identifiés : des circuits longs (distance et nombre d'intermédiaires) pour les produits non périssables (céréales, niébé, sésame, volaille et bétail) et des circuits courts pour les autres produits (oignon, la tomate et PFNL,). Selon DABAT et al., (2012, pp. 62-63), l'analyse des transactions entre les acteurs permet d'identifier trois circuits possibles dans la chaîne de commercialisation : un circuit interprovincial et transfrontalier, un circuit local et un circuit critique (qui concerne la vente au-delà des excédents de production et les ventes contraintes par certains producteurs de céréales).

L'impact des politiques publiques

Les politiques publiques peuvent également avoir des répercussions sur la disponibilité des produits en quantité en qualité et sur les prix sur le marché, qui se répercutent à leur tour sur le niveau de vulnérabilité des ménages. De ce point de vue, ces politiques peuvent être une opportunité pour s'adapter aux risques mais également comme facteur de vulnérabilité des ménages. Ainsi, les crises sanitaires ayant touché le commerce de la viande au cours des dernières décennies et la crise alimentaire des années 2007 et 2008 ont lourdement pesé sur la politique commerciale agricole du Sénégal. D'abord, plusieurs mesures commerciales visant à protéger les consommateurs des risques liés aux crises sanitaires de 2000 et de 2005 ont été prises au Sénégal : renforcement du contrôle des produits importés de la filière viande bovine en 2000 ; suspension des importations de viande de volaille en 2005; etc.

Ensuite, entre 2007 et 2008, le Sénégal à l'instar de plusieurs pays en développement avait pris des mesures visant à limiter l'impact de la hausse des prix sur leurs marchés nationaux : suspension de la

TVA et des droits de douanes (DD) sur le lait en poudre en 2007 ; suspension des droits de porte sur le riz brisé (toutes variétés confondues), le blé et les emballages contenant du riz.

Enfin, des mesures visant à augmenter la production de céréales par le biais d'investissements productifs et l'octroi de facilités aux producteurs pour accéder aux intrants ont été prises: Grande Offensive Agricole pour la Nourriture et l'Abondance (GOANA).

Si plusieurs études ont souligné l'impact de ces mesures sur la disponibilité alimentaire et les revenus des systèmes de productions (CILSS, 2010; GERGELY N. et BARIS P., 2009; Lançon F. et Mendez del Villar P.; 2012), peu de travaux se sont intéressés à leur impact sur les différentes catégories d'acteurs (consommateurs, producteurs commerçants, importateurs, industriels, exportateurs, etc.).

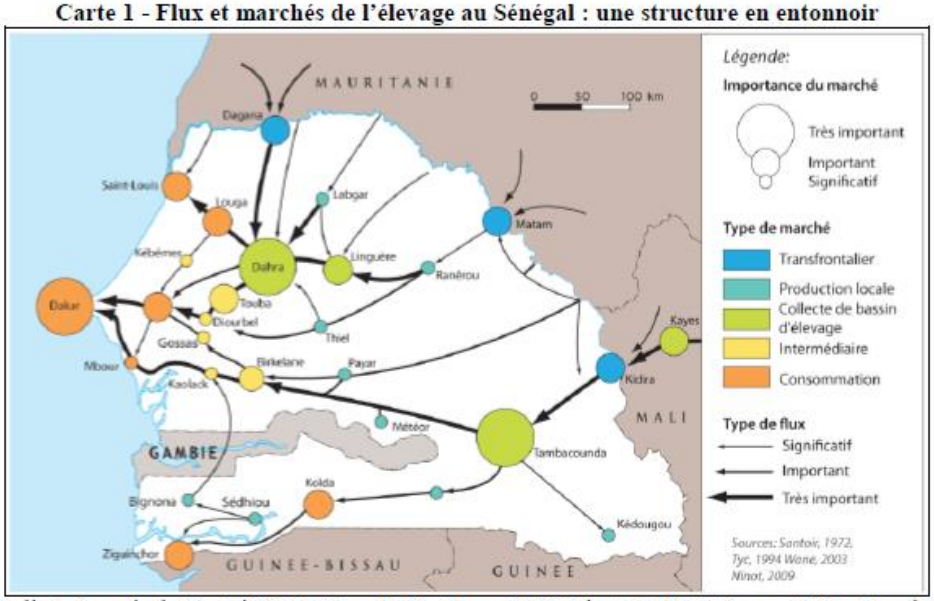
Pour la GOANA par exemple, plusieurs études (CILSS, 2010, Gergely N. et Baris P., 2009) ont montré que ce programme a été actif durant la campagne 2008-2009. Ainsi, elle avait contribué à l'augmentation de la production de riz local au Sénégal et par conséquent une amélioration des disponibilités alimentaires sur les marchés. En ce qui concerne la suspension de la TVA et des DD sur le lait en poudre qui visait à subventionner les prix à la consommation, elle n'avait pas eu les effets escomptés. En effet, malgré l'application de cette mesure pour une durée d'un an (Juillet 2007 à Septembre 2008), on avait assisté à une augmentation des prix du lait en poudre, une baisse des quantités importées, une baisse des recettes douanières, (Ngom Y., 2013 et Dia D. et al. 2008) etc. Ces deux exemples montrent que l'impact des politiques publiques, sur les prix, l'accessibilité et la qualité des produits sur le marché, peut être aussi bien une opportunité et/ou une source de vulnérabilité des systèmes de production. D'ou la nécessité pour les pouvoirs publics de mettre en place des politiques commerciales en fonction des spécificités de chaque filière visant à améliorer l'accès des ménages aux produits alimentaires de base comme le riz ou à faciliter l'écoulement des productions des ménages

Les circuits de commercialisation

Les caractéristiques d'une zone (poids administratif et démographique, situation géographique, mouvements de la population) peuvent influencer la disponibilité et la circulation des produits dans l'espace et dans le temps. Ainsi, les circuits de commercialisation varient en fonction des zones de production, des produits, des périodes de l'année (saisons, fêtes religieuses, etc.). De façon générale, le bassin ouest (Gambie, Guinée Bissau, Mali, Mauritanie et Sénégal) est parcouru par des flux commerciaux de longue distance qui sous tendent les revenus et la sécurité alimentaire des producteurs ruraux : huile de palme, bétail, anacarde, arachide (CILSS, 2010). Notre zone d'étude (régions de Tambacounda et de Matam) présente la plus faible densité de la population (9,5% population nationale et 36,4% superficie nationale, SES 2010), ce qui ne favorise pas la présence de marchés dynamiques surtout en zone rurale. Toutefois, la proximité avec les pays frontaliers (Mali, Mauritanie et Guinée) donnent de l'importance à certains marchés urbains (Tambacounda et Matam) particulièrement pour les produits céréaliers et le niébé (Kayes), l'huile de palme et les produits tropicaux (Diaobé via Guinée Bissau et Guinée), le bétail (Kiffa et Kayes).

Au Sénégal, les circuits marchands convergent principalement vers la région de Dakar. Toutefois, d'autres marchés de consommation importants tels que Saint-Louis, Touba, Kaolack ou Thiès présentent aussi des débouchés non négligeables. Cette carte visualise les marchés du bétail et montre surtout que notre zone d'étude, située dans une région frontalière, permet d'intensifier les échanges avec les marchés des pays limitrophes (Mali et Mauritanie). Dahra est le principal marché de collecte et de redistribution du Sénégal (cf. carte ci-dessous).

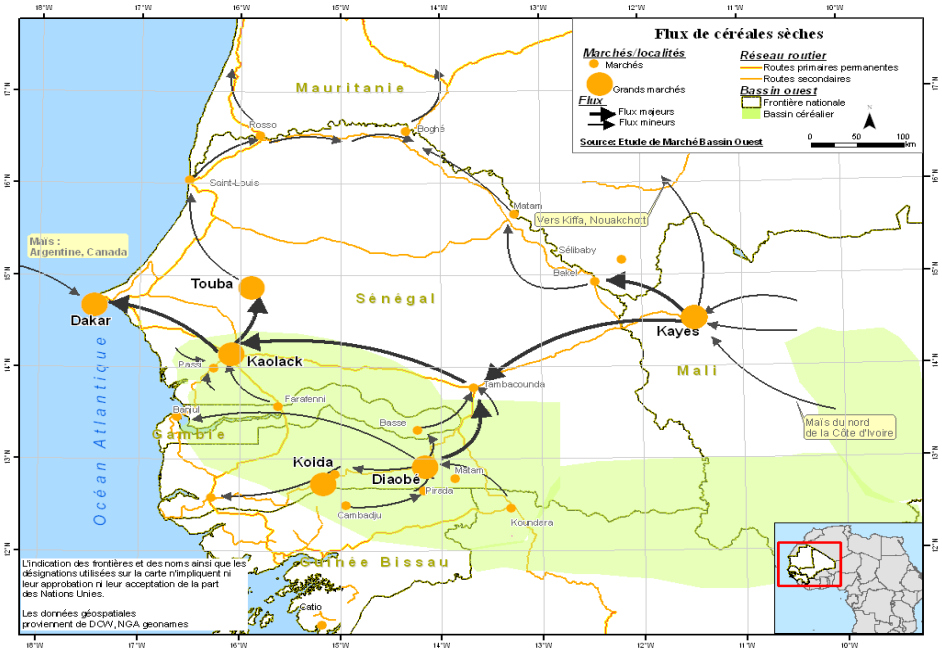
Carte 1 - Flux et marchés de l'élevage au Sénégal : une structure en entonnoir



Source : réalisée à partir de Santoir 1972, Tyc, 1994, Wane 2005, Ninot, 2010 In Cesaro J. D., Magrin G., Ninot O., 2010, *Petit atlas de l'élevage au Sénégal : Commerce et territoire*, p. 15

En ce qui concerne les céréales sèches, une partie de la production connait des circuits de commercialisation courts, limités à la localité car elle est autoconsommée ou vendue dans les marchés de proximité. Comme l'indique la carte ci-dessous, une autre partie peut connaitre un circuit long car pouvant provenir ou être vendu en dehors de la région ou même dans les pays frontaliers. Pour ces circuits longs, les produits convergent généralement vers Touba, Kaolack et Tambacounda, Diaobé et Dakar. A titre illustratif, Kaolack est le marché-leader pour le mil (CILSS, 2010).

Carte 2: Flux des céréales sèches



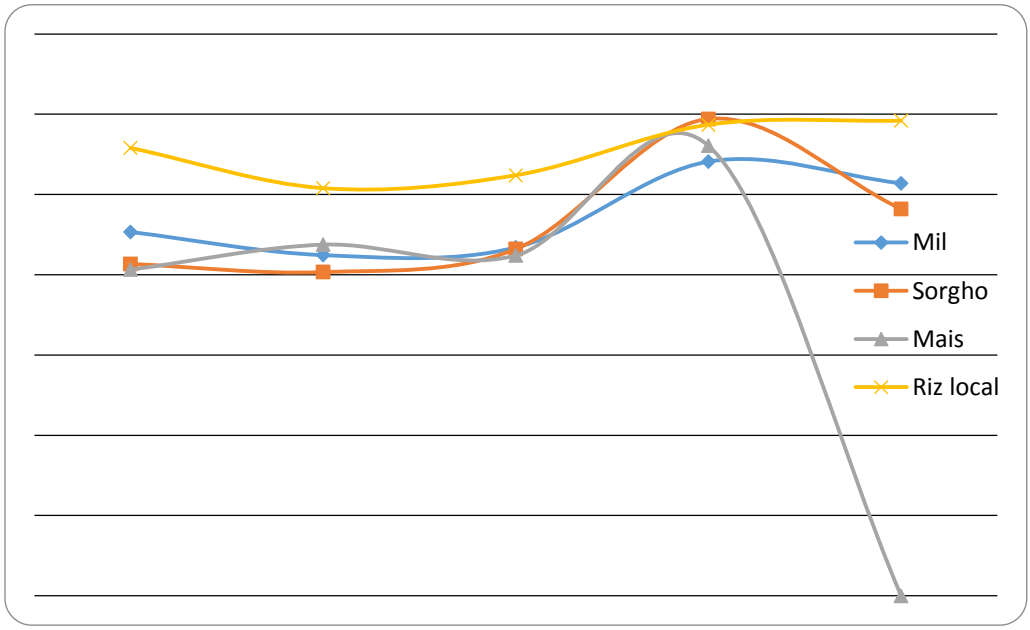
Source: CILSS 2010

La formation des prix

Les prix jouent un rôle important dans l'offre de marché et leurs mécanismes de fixation varient selon le type de marché. La formation du prix des produits est déterminée par un ensemble de paramètres : nombre d'intermédiaires dans la filière, volume échangé, période de commercialisation, durée du stockage, disponibilité et qualité du produit, distance entre lieu d'approvisionnement et lieu de revente, coût du transport, qualité des voies d'accès, taxes et « tracasseries » douanières, culture et relations sociales, fréquence d'ouverture des marchés, disponibilité des moyens de transport, pluviométrie, détention de l'information, etc. (DABAT et al., 2012, p.8). Généralement, les marchés de groupement sont faiblement influencés par l'extérieur dans la fixation des prix. Au niveau des marchés hebdomadaires, les prix sont souvent fixés par les grossistes en position dominante alors que dans les marchés de consommation, les prix sont principalement du ressort des commerçants. Les circuits de commercialisation courts peuvent avoir un impact sur les revenus des exploitations vulnérables dans la mesure où il y a moins d'intermédiaires et les coûts de transaction sont faibles, ce qui peut avoir une répercussion positive sur la formation des prix. De même, la demande urbaine et ou industrielle relativement importante permet aux exploitations de se positionner sur des niches porteuses (oignons, PFNL, riz, tomate), malgré les coûts de transport et de stockage. La conservation et le stockage de la production constituent des stratégies d'adaptation qui peuvent avoir des répercussions sur les prix au producteur et augmenter les revenus des ménages.

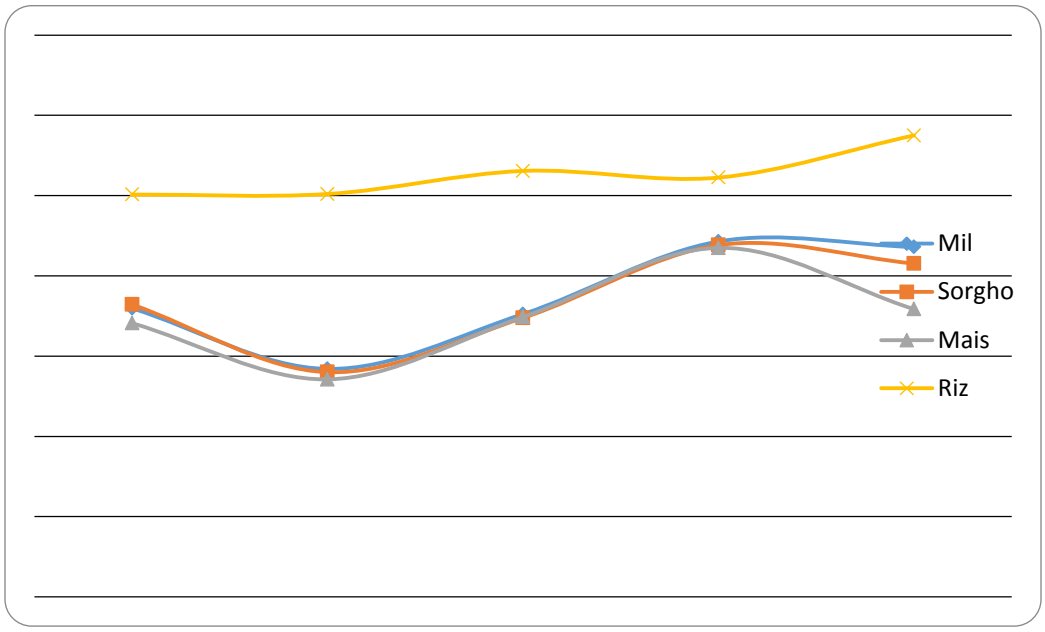
Ces différents paramètres que nous venons d'aborder font que les prix des céréales et du bétail varient en fonction des régions et même des années. Dans les régions de Matam et de Tambacounda par exemple, les prix des céréales ont connus de fortes variations durant les cinq dernières années. Si nous prenons le cas des céréales sèches (Mil; Sorgho et Maïs), les prix ont connus des périodes de baisse (2010 et 2013) et de hausse (2011 et 2012) durant les cinq dernières années. En ce qui concerne le riz, la tendance est généralement à la hausse depuis l'année 2010 **(Figures 1 et 2).**

Figure 1: Evolution annuelle des prix des céréales dans la région de Matam



Source: Commisariat à la Sécurité Alimentaire (CSA), 2013

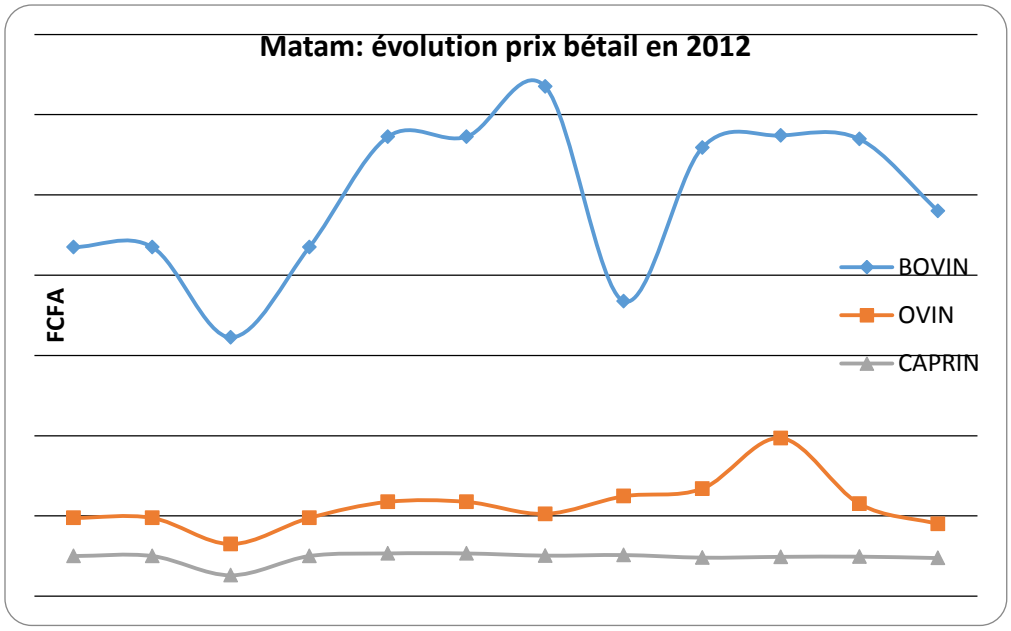
Figure 2: Evolution annuelle des prix des céréales dans la région de Tambacounda



Source: Commisariat à la Sécurité Alimentaire (CSA), 2013

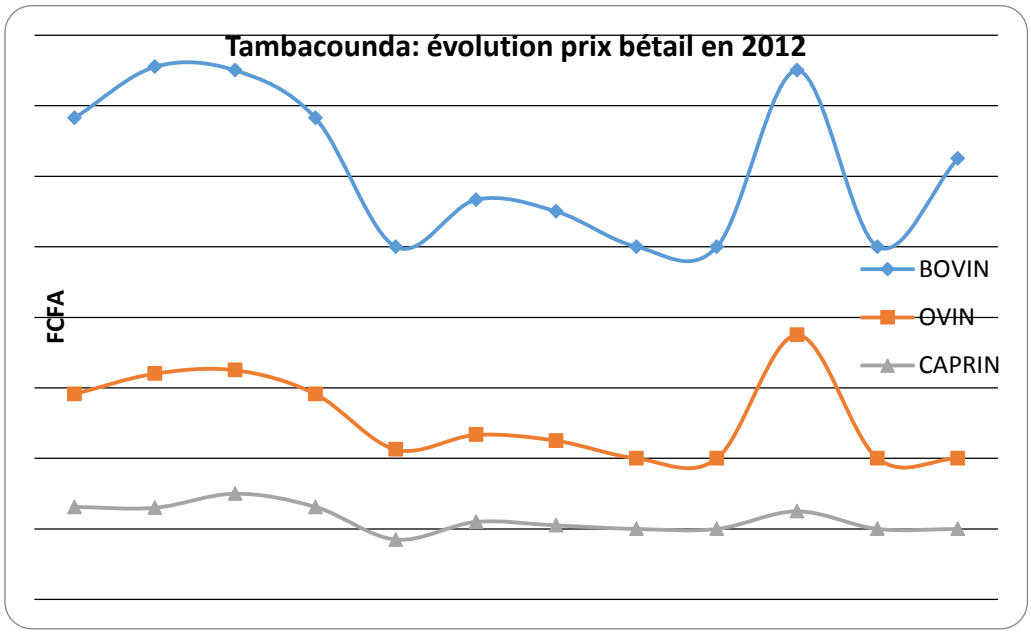
En ce qui concerne le bétail, les prix varient en fonction des périodes de l'année, dans les régions Matam et de Tambacounda. Ainsi, durant les périodes de fêtes religieuses (tabaski, fêtes de fin d'année), on note une forte consommation de viande de bovins et d'ovins qui se répercute sur les prix; qui sont plus élevés Pour l'année 2012, la hausse des prix des ovins au mois d'octobre s'explique par l'approche de la tabaski (Aid El fitr) ou il y a une forte demande de moutons **(cf. figure 3 et 4).**

Figure 3: Evolution mensuelle des prix du bétail dans la région de Matam (2012)



Source: Commisariat à la Sécurité Alimentaire (CSA), 2013

Figure 4: Evolution mensuelle des prix du bétail dans la région de Tambacounda (2012)



Source: Commisariat à la Sécurité Alimentaire (CSA), 2013

Le marché : facteur de vulnérabilité

Dans les dernières décennies, l'insertion généralisée de l'agriculture à l'économie de marché, associée à la monétarisation des échanges a contribué à renforcer un nouveau type de risque qu'on peut qualifier de «*risque économique*». Les exploitations, engagées dans une intensification supposée améliorer la compétitivité de leurs produits, sont souvent endettées. La plupart du temps, elles sont dépendantes des prix imposés. Les paysans produisent mais ne sont pas sûrs d'écouler leurs produits à un prix rémunérateur ; comme la part de l'autoconsommation est de plus en plus réduite, la survie même des exploitations agricoles, voire des familles, est alors compromise.

Les facteurs de vulnérabilité des régions, localités vis-à-vis du marché

Les facteurs qui peuvent expliquer la vulnérabilité des localités par rapport au marché sont l'insuffisance et la mal répartition des marchés, la fréquence d'ouverture des marchés, la distance par rapport aux marchés hebdomadaires, de regroupement ou de consommation, et les faibles capacités de stockage.

En milieu rural, les localités (villages, hameaux) disposent de marchés quotidiens dont l'offre en produits agricoles est parfois insuffisante et instable. En outre, la plupart des grands marchés ruraux sont hebdomadaires (loumas), ce qui limite les transactions des produits agro-sylvo-pastoraux.

L'éloignement de certains villages par rapport aux routes aux marchés hebdomadaires, de regroupement ou de consommation, la rareté des routes goudronnées, les pistes impraticables en saison pluvieuse, les marchés éloignés des voies principales, portent préjudice à l'évacuation des produits des zones de production vers les zones déficitaires. Ainsi, les travaux de Wane et al. (2008) ont montré que la commercialisation des produits périssables comme le lait frais par exemple est moins importante dans les sites les plus enclavés (Mbame), que dans les sites proches des routes goudronnées (Boulal). Selon ces auteurs, le type marché (louma, marchés de regroupement et de consommation) influe également sur la structuration des ventes de produits d'élevage (bovins, ovins, caprins, lait frais ou caillé, beurre, etc.). Selon eux, "*la différence entre Boulal et Thiel s'explique également par la proximité du marché de Dahra.*

Le plus gros marché régional de regroupement de bétail joue un rôle spécifique sur les ventes comparativement au rôle limité des marchés de brousse (luma) tels que Thiel. Dans les sites isolés comme Mbame, les ventes concernent exclusivement les produits stockables (beurre).

Le manque d'équipement de stockage en sus des coûts de stockage élevés, constituent une contrainte fondamentale au bon fonctionnement des marchés dans les zones d'étude (Matam et Tambacounda). De plus, l'absence d'électricité en zone rurale constitue un frein au développement d'infrastructures modernes (chambre froide pour les produits périssables) qui permettraient une qualité et une durée de stockage plus importante.

Les facteurs de vulnérabilité des ménages (intégration au marché)

Les facteurs qui influencent l'accès des ménages aux produits alimentaires et aux intrants agricoles sont le niveau ou la variabilité des prix, la disponibilité des produits, le faible pouvoir d'achat des petits producteurs, et le faible accès au crédit.

Le niveau et la variabilité des prix peuvent être source de vulnérabilité des ménages. En effet, l'inondation des marchés par les ventes forcées (période de forte de production, période de sécheresse) provoque une chute des prix particulièrement néfaste pour des populations déjà appauvries. Certains acteurs des filières de produits agricoles ont plus de marge de manœuvre sur la formation des prix, que d'autres. De manière générale, les commerçants ont plus de poids que les producteurs et les consommateurs dans la fixation des prix. Les difficultés pour accéder aux crédits et les intermédiaires (grossistes, demi-grossistes, détaillants, etc.) qui interviennent dans la commercialisation influent également sur les prix des produits agricoles, réduisant ainsi l'accès des ménages aux produits alimentaires de base. L'endettement auprès des prêteurs sur gages va ainsi se répandre et favoriser la vulnérabilité des populations.

La fragilisation des secteurs d'activités de rentes (crise filière arachide, diminution produits halieutiques, faible développement des cultures maraichères, etc.) a fini par diminuer le pouvoir d'achat des ménages qui disposent ainsi de moins de liquidités pour faire face à leurs besoins primordiaux. En effet, la principale source de revenu pour la majorité des populations de la zone est soumise à l'instabilité des prix qui peuvent entrainer des productions insuffisantes sur des périodes de plus en plus longues.

Le régime alimentaire des ménages est généralement basé sur les céréales, les légumes, le poisson, et les légumineuses comme le niébé et l'arachide. Les céréales représentent environs les 2/3 des disponibilités énergétiques mais avec l'influence de la variabilité climatique, nous notons une forte variabilité de la production, particulièrement du mil et du sorgho favorisant ainsi une dépendance des agriculteurs du marché.

Le comportement des marchés des produits agricoles est très peu maitrisé. La réduction de la volatilité des prix est considérée comme essentielle pour mieux maitriser ces marchés. Ainsi, différents mécanismes de régulation peuvent être mis en place pour assurer une meilleure visibilité au niveau des marchés. Ainsi, pour limiter les fluctuations des prix au cours des campagnes agricoles et favoriser une stabilité des marché, il faudra favoriser une mise en marché collective pour jouer sur les économies d'échelle, remettre à jour les coopératives qui ont montré leur importance du temps de l'ONCAD, développer les interprofessions qui permettent une meilleure maitrise de l'intégration au sein des filières, créer des observatoires de marchés pour favoriser une meilleure circulation de l'information. D'autres mécanismes de régulation du marché peuvent être développés pour limiter les variations au niveau annuel par le biais de stratégies de stockage (stockage de sécurité, stockage à des fins de régulation de la mise en marché des produits, le stockage d'intervention, …), des marchés à terme, de la contractualisation entre organisations paysannes et opérateurs économiques, le warrantage, …En ce qui concerne le financement des activités agricoles et d'élevage, Touré (2013) a montré qu'il existe très peu de financement formel (banque, institutions de microfinance) pour les producteurs agricoles et surtout

pour les éleveurs. La plupart des financements obtenus proviennent des circuits informels (parents, autoconsommation, financement des tiers). Les producteurs qui bénéficient le plus souvent de financements formels sont généralement membres d'interprofessions regroupant des filières relativement bien organisées et liés par des contrats de vente de produits avec des industriels (tomate). Plus spécifique, les financements sont quasi exclusivement destinés à des productions commerciales (tomate, riz). Les cultures vivrières, comme dans le cas de notre zone d'étude, ne bénéficient d'aucun système de financement (Touré, 2013).

En effet, les activités agricoles sont exclusivement financées par des fonds propres issus de l'épargne des ménages ou des revenus de transferts. Les intrants agricoles, notamment les semences et engrais sont achetés au comptant même lorsqu'ils sont subventionnés par l'Etat. Les coopératives d'achat, de distribution et de vente sont inexistantes (voir supra) et les organisations paysannes sont plus axées sur la défense des intérêts (plaidoyer) que sur la recherche et promotion de systèmes de coopération pour le financement des activités.

Pour les éleveurs, l'achat d'aliment bétail se fait également au comptant, de même que les produits vétérinaires qui ne bénéficient pas de subvention de la part de l'Etat.

Les facteurs de vulnérabilités intrinsèques aux systèmes de productions

Pour les systèmes de production, la vulnérabilité face au marché peut être due aux conditions de transport des marchandises, à la volatilité des prix, la concurrence des produits importés et au faible accès au crédit.

Pour certaines filières (viande de volaille, lait, le mil, le sorgho, etc.), la production des systèmes d'exploitation agricoles et pastorales est très sensible aux importations, parce que faiblement compétitif et par conséquent concurrencés par les produits agricoles d'autres pays. En effet, les agriculteurs des pays exportateurs bénéficient généralement de subventions qui contribuent à faire baisser les prix par rapports aux prix des producteurs des marchés domestiques, qui ne disposent pas de subventions. Cette concurrence déloyale accentue généralement la vulnérabilité des agriculteurs. La concurrence des produits importés peut être également une opportunité pour ces exploitations. En effet, certains travaux de recherches (Dia D. et al. 2008, Diarra A., 2009 et Ngom Y. 2013) ont montré que la libéralisation des échanges présente des opportunités et des contraintes suivant les filières. Au Sénégal, l'ouverture ou l'internationalisation du commerce facilite non seulement l'approvisionnement des marchés en denrées de base et en produits transformés (riz et le lait) mais aussi elle offre de nouvelles opportunités à l'exportation de certains produits (produits horticoles, cuirs et peaux). La libéralisation des échanges peut, d'une part, fragiliser les productions locales sur les marchés nationaux (cas de viande de volaille entre (2000 et 2005), et d'autre part, être source potentielle d'insécurité alimentaire à cause des risques de volatilité des prix sur les marchés mondiaux (cas du lait en poudre entre 2008 et 2010).Les grands marchés de consommation sont généralement caractérisés par une demande en produits alimentaires qui est quasi fixe et une offre qui est extrêmement variable. De ce fait, de petites variations de l'offre vont produire des fluctuations de prix de plus grande ampleur. En effet, en période de forte production, les prix de certaines denrées ont tendance à baisser et vice-versa. Cette volatilité des prix sur les marchés agricoles nationaux et internationaux a souvent des répercussions sur la consommation des ménages mais également sur les revenus des systèmes de production.

Cette vulnérabilité et les capacités d'adaptation aux risques varient en fonction du type de système de production (pastorale, agricole, etc.). A ce sujet, certains travaux de recherche sur la vulnérabilité (Mertz et al., 2010) ont montré que les systèmes pastoraux sont moins sensibles aux changements climatiques que les systèmes de production qui dépendent principalement des cultures agricoles (céréales). Ce constat est étroitement lié aux stratégies d'adaptation des systèmes de production pastorale, qui sont combinées entre elles, de manière à accroître leurs effets et impacts sur les budgets familiaux et les troupeaux. Ainsi, en réponse à la disponibilité des ressources (eau et pâturage), les

troupeaux peuvent être déplacés vers d'autres zones plus favorables. Partant de là, la distinction entre ces deux systèmes de production s'impose.

Systèmes de production Agricoles

Comme l'indique certaines données statistiques (CILSS, 2000) la totalité des systèmes de production vivriers essentiellement axés sur les céréales sont très vulnérables.

Les systèmes de production céréalière se caractérisent par une stratégie visant une production destinée à l'autoconsommation au niveau du ménage. Cette production céréalière est uniquement basée sur une agriculture pluviale qui ne permet pas souvent de couvrir les besoins céréaliers. Cette situation entraine une forte demande en produits céréaliers sur les marchés, ce qui peut engendrer une hausse des prix.

Dans les systèmes de production de rente, les espèces cultivées sont principalement le coton, l'arachide et le niébé. Ces produits permettent de disposer des revenus mais l'instabilité observée sur les marchés internationaux ou les prix sont fixés sans eux pourrait favoriser leur vulnérabilité. De même, la spécialisation dans les cultures de rentes (coton, arachide, niébé de plus en plus) peut se développer au détriment des cultures de consommation familiale et entraîner une grande dépendance vis-à-vis de marchés (national et international). Cette situation peut pousser à plaider pour des politiques agricoles favorisant la diversification des cultures (cultures vivriers, cultures de rentes et cultures horticoles).

Systèmes de production Pastoraux

Les systèmes de production pastoraux se caractérisent essentiellement par des déplacements saisonniers sur une longue distance. Ils approvisionnent également les marchés ruraux et parfois urbains en produits animaux (petits ruminants, bovins, etc.) et en sous-produits (lait cru, lait caillé, babeurre, huile de beurre, etc.). Selon Wane et al. (2010), les ventes réalisées entre la fin de la saison des pluies 2004 et celle de 2005 représentent 692 millions de F CFA (1,055 million d'euros). Ces recettes proviennent des ventes d'animaux de rente (bovins, ovins, caprins) à 97,9%; des produits laitiers (lait frais, lait caille´ et beurre) à 0,5 % ; des asins et équins a` 0,8 % et des cultures (mil, gomme arabique, produits de cueillette – jujubes, fruits de balanites) a` 0,8 %. L'accès aux produits alimentaires se fait par l'achat de céréales. La contrainte principale est l'insuffisance des aliments sur les marchés et la détérioration des termes de l'échange. Cette situation les rend vulnérables surtout en période de soudure.

Ainsi, les principaux facteurs de vulnérabilité des systèmes pastoraux sont l'accessibilité et la disponibilité des ressources en eau et en pâturage. L'accès à ces ressources naturelles est souvent entravé par les principaux événements intervenus dans la zone que sont les sécheresses répétées, les feux de brousse, les pluies contre saison, les pannes prolongées du forage, l'arrivée massive de transhumants en provenance d'autres zones; etc.

Les attitudes, comportements et reflexes des pasteurs répondent souvent à un souci de prévention et de gestion de ces principaux événements. Les stratégies adoptées par ces pasteurs ne sont forcément en relation avec le marché, mais à chaque fois que le besoin se fait ressentir, ils sont obligés d'aller vers le marché qui présente des réalités qui ne sont pas souvent en leur faveur (volatilité et niveau des prix, indisponibilité des produits, mauvaise qualité des voies d'accès, marchés hebdomadaires, etc.). Dans la zone de Téssékré, dans le Ferlo, par exemple, "*les familles qui parient sur la petite agriculture pluviale comme stratégie de survie semblent éprouver de grandes difficultés à satisfaire leurs besoins alimentaires et à relancer leur activité d'élevage*" (Touré et al., 2010, p.28). Ce qui les oblige à se tourner vers le marché pour satisfaire leurs besoins alimentaires. Dans le même sillage, Bilkiss et Wane (2008), ont montré qu'en période de crise (sécheresse, flambée des prix des céréales, etc.), la majeure partie des animaux, surtout les taureaux et même les vaches suitées ou non, est commercialisée pour subvenir à des besoins (….). "*Or le besoin n'attend pas que les prix soient favorables ou non sur le marché. La marge de manœuvre*

des éleveurs demeure alors dans les possibilités d'anticipation et dans la détermination du type d'animal à vendre pour minimiser les pertes". C'est la raison pour laquelle les pasteurs saisissent certaines opportunités (approche des grandes fêtes religieuses comme Aid El Kabir) pour maximiser leur gain (Wane et al. 2010). En définitive, on note la co-existence de deux stratégies de commercialisation des pasteurs: celle qui consiste à vendre pour subvenir à des besoins et celle qui consiste à saisir les opportunités pour maximiser le profit.

CONCLUSION

La vulnérabilité est un concept polysémique. Plusieurs approches de la vulnérabilité sont développées : écologiques, économiques, sociologiques et "*mixtes*". Dans le cadre de cette revue bibliographique, la vulnérabilité a été définie suivant une approche systémique en tenant compte des trois dimensions suivantes : écologique, économique et sociale. En effet, les dimensions environnementale et économique de la vulnérabilité ont été au cœur des analyses tandis que la vulnérabilité sociale a été mise en avant principalement dans les études sur les systèmes de production pastorales. Nous prêterons attention dans cette étude à ces trois dimensions quel que soit le système de production.

La vulnérabilité des ménages ruraux prend de plus en plus de l'ampleur, particulièrement dans notre zone d'étude, du fait de plusieurs facteurs qui ne sont pas forcement liés aux changements climatiques. C'est pourquoi, une meilleure compréhension des dynamiques socioéconomiques en cours est nécessaire. En effet, le comportement des marchés est très peu maitrisé du fait de facteurs internes comme la variabilité de la production intra et/ou interannuelle, du cloisonnement des marchés et de la concurrence imparfaite ; mais aussi de facteurs externes tels que la volatilité des marchés internationaux ainsi que les conséquences de la réglementation internationale (OMC) sur les marchés et les producteurs locaux.

Cette recherche bibliographique a montré que le marché peut constituer une opportunité pour les systèmes de production mais également être source de vulnérabilité. D'une part, les marchés peuvent être sources de revenus (vente de la production agricole, du bétail et des produits de cueillette) et d'alimentation pour les exploitations agricoles. Ils peuvent également constituer une opportunité si l'offre est disponible en quantités et en qualité, diversifiée et constante.

D'autre part, les marchés peuvent être aussi source de vulnérabilité des localités, des ménages et des systèmes de production du fait d'une forte demande face à une offre très limitées (variabilité de l'offre, instabilité des prix, etc.), de la fréquence des marchés (hebdomadaires), des difficultés liées au transport (qualité des routes), des faibles capacités de stockage (problèmes d'électricité), de la concurrence des produits importés et du faible accès au crédit. Cependant, plusieurs mécanismes peuvent être développés pour réduire la vulnérabilité au sein des marchés et des producteurs entre autre le développement des dispositifs interprofessionnels (arachide au Sénégal, riz avec copérative Mogtédo au Burkina Faso, …), la création d'observatoires des marchés efficaces pour anticiper les volumes à commercialiser, le développement de la contractualisation (marché à terme, …) pour limiter les variations interannuelles (contractualisation FPE au Sénégal).

La configuration actuelle des marchés permet-elle d'atténuer la vulnérabilité des ménages? Quels sont les marges de manœuvre dont disposent les systèmes de production pour réduire leur vulnérabilité? Tels sont les types de questions qu'on peut se poser pour poursuivre cette réflexion en milieu réel. Les données d'enquêtes ménages et des focus group au niveau des zones ciblées permettront de répondre à ces questions.

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ANNEX O. MODELISATION DES RESSOURCES PASTORALES A L'HORIZON 2030 ET 2050

2014

CSE

Modélisation des ressources pastorales à l'horizon 2030 et 2050.

Centre de Suivi Ecologique

Pour la Gestion des Ressources Naturelles

Summary:

In Sahel, traditionally extensive livestock breeding faces the full force of the effects of climate change. Indeed, the grazing resources strongly depend on the climate conditions, rainfall in

[MODELISATION DES RESSOURCES PASTORALES FACE AUX CHANGEMENTS CLIMATIQUE A L'H'ORIZON 2030 ET 2050]

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particular. The eastern part of Senegal has not escaped this phenomenon. The purpose of this study is to better understand the effects of climate change on these grazing resources in this part of the country. For this reason, climate scenario models were used for predictions. The results show that in the north part of our study zone, the fodder deficit will be strongly felt and will mirror what was experienced in 1992, or worse. This situation risks being aggravated by the reduction of the duration of pond flooding.

In the south part, the deficit cannot be felt. However, the increase of the agricultural land that overlaps the pasture areas and national and international transhumance can cause a deficit. It is also the case that a drop in precipitation can lead to the disappearance of certain fly species, which at this time has hindered the development of certain herbivore races.

Résumé :

Au Sahel, l'élevage traditionnellement extensif subit de plein fouet les effets des changements climatiques. En effet les ressources pastorales sont fortement dépendante des conditions climatiques notamment la pluviométrie. La partie orientale du Sénégal n'a pas échappée à ce phénomène. L'objectif de cette étude est de mieux comprendre les effets des changements climatiques sur ces ressources pastorales dans cette partie du pays. Pour cette raison, la modélisation a été utilisée pour prédire en fonctions des scénarios climatiques. Les résultats montre que dans la partie nord de notre zone d'étude, le déficit fourrager sera très ressenti et sera à l'image de ce qui a été vécu en 1992 ou pire. Cette situation risque d'être aggravée par la diminution de la durée d'ennoiement des mares.

Dans la partie sud, le déficit peut ne pas être sentit. Cependant, l'augmentation des superficies agricoles qui empiète les zones de pâturages, la transhumance nationale et internationale peuvent entrainer un déficit. A cela s'ajoute le fait qu'une baisse des précipitations peut entrainer la disparition de certains espèces te mouches qui constituent jusque là un frein au développement de certaines races d'herbivores.

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II- Présentation de la zone

II-1- Sol

II-2- Végétation

II-3- Climat

II-4- Ressources hydriques

II-5- Elevage

II-6- Agriculture

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III-1-3- Les données sur le cheptel

III-1-4- Les données sur les ressources hydriques

III-1-5- Les données sur les rendements agricoles

III-2- Méthodologie

III-2-1- Modélisation de la biomasse

III-2-2- Modélisation des ressources hydriques

III-2-3- Modélisation du fourrage post-récolte

IV- Résultats et discussions

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IV-3- les ressources hydriques en 2030 – 2050

V- Conclusion

I- Introduction

Depuis plusieurs années, l'état de l'environnement est devenu une préoccupation majeure de la communauté scientifique internationale (GEO-4, 2007 ; IPCC, 2007; AEO-2, 2006). Les effets néfastes des changements climatiques sur les écosystèmes, les ressources naturelles et les divers secteurs socio-économiques se font de plus en plus sentir (MEPN, 1997 ; MEPN, 2010), engendrant des conséquences non négligeables sur la vie des populations. L'élevage, qui constitue un des piliers de l'économie du Sénégal, est elle aussi sensible aux changements climatiques. En effet, la biomasse qui est la principale nourriture des animaux, est fortement tributaire de la pluviométrie. Ce qui fait de cette de l'élevage un secteur particulièrement vulnérable face aux changements des régimes de pluies. Face à cette situation, il urge de chercher à mieux évaluer les effets de ces changements sur les ressources naturelles et leur impacts sur la vécu des populations afin de pouvoir proposer des mesures d'atténuation et d'adaptation. C'est dans ce cadre que le CSE a été chargé de faire une étude sur l'estimation de l'impact attendus des changements climatiques sur les ressources pastorales pour les périodes 2030 et 2050. L'objectif est de mieux comprendre l'impact des changements climatiques sur les ressources pastorales et de facto sur l'élevage. Cette étude vise à estimer la production fourragère des années à venir en tenant compte des différents scénarios climatiques. Elle est faite à partir du modèle STEP (***S****ahelian****T****ranspiration****E****vaporation and* ***P****roduction model*). Ce modèle permet à partir des données climatiques, d'estimer la production de fourragère. C'est un modèle mathématique qui a été validé sur l'ensemble de la bande sahélienne.

L'étude cette se concentre sur la partie orientale du pays ou l'élevage joue un rôle de premier plan dans l'économie des ménages. Cette zone, de par son caractère pastoral, mérite une attention particulière eu égard à la vulnérabilité de ses populations face aux changements climatiques. En effet, les ressources pastorales (biomasse, mares, etc.) qui sont fortement tributaires de la pluviométrie, et de la température dans une moindre mesure, peuvent être fortement affectées. L'objet de cette étude est de chercher à évaluer le comportement des ressources pastorales à l'horizon 2030-2050, cela en tenant compte des scénarios climatiques. L'objectif de cette étude est d'investir plus efficacement et de manière cohérente dans la programmation et les activités d'adaptation qui favorisent la croissance économique, la gouvernance démocratique, la santé, les droits humains et l'éducation ; comprendre les mécanismes de vulnérabilité pour mieux cibler les stratégies d'intervention de l'USAID (programmes qui favorisent la résilience).

Ce rapport comprend trois parties :

-La présentation de la zone d'étude qui donne un aperçu global des caractéristiques physique de la zone mais aussi des activités socio-économiques prédominantes ;

- la méthodologie ainsi que les données utilisées comme input pour faire l'étude

- les résultats et discussions constituent la dernière partie de ce document.

II- Présentation de la zone

La zone d'étude se trouve dans l'est du Sénégal, à cheval entre les régions de Matam et de Tambacounda (figure-1) ; pour les besoins de l'étude elle peut être subdivisée en deux sous-zones (nord et sud) en suivant approximativement l'hysoyète annuelle de 600mm.

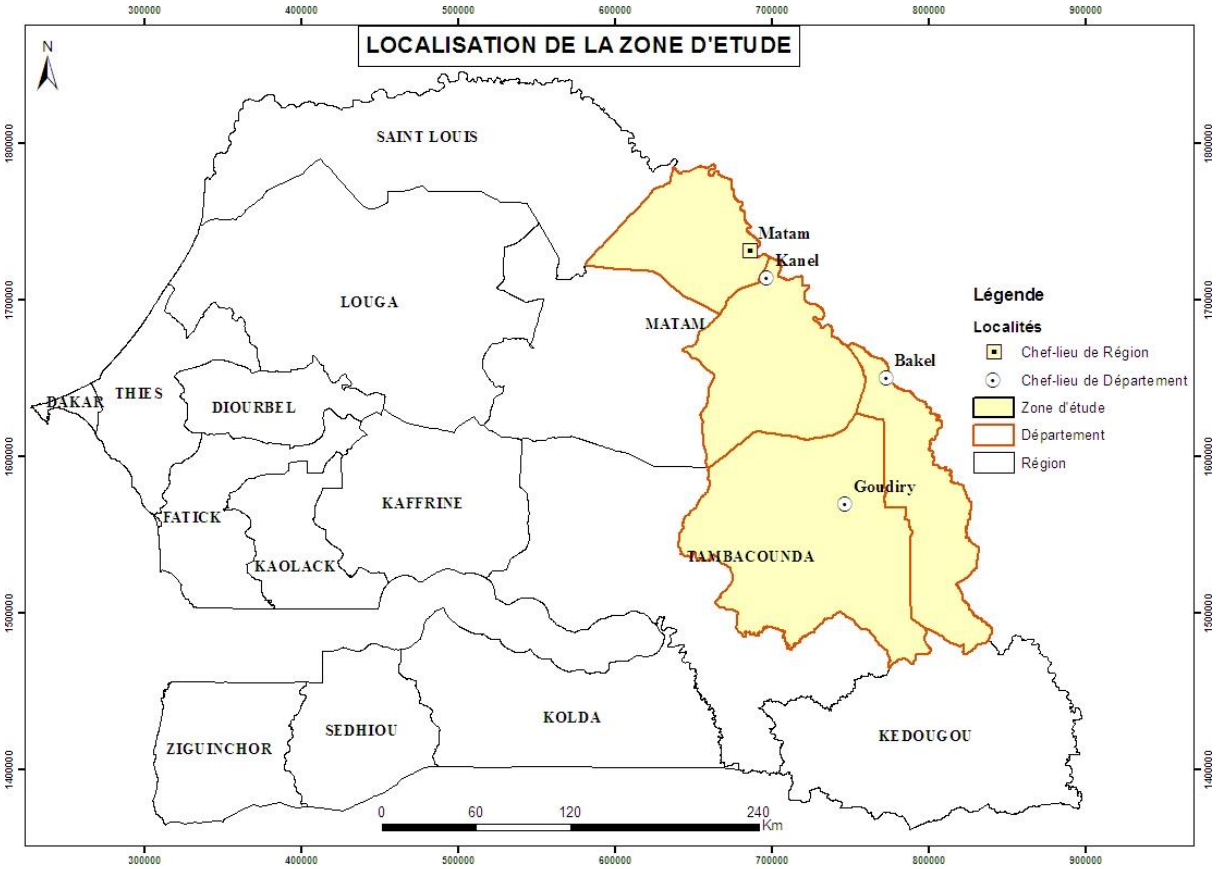

Figure-1 : Localisation de la zone d'étude (source base de données CSE)

La zone nord de l'étude (départements de Matam et Kanel) est située dans la région de Matam en zones sahéliennes et soudano sahéliennes. Elle est à cheval entre les zones éco géographiques : vallée du fleuve *Sénégal* et zone sylvo-pastorale du *Ferlo* plus précisément entre les sous zones Haute vallée et Ferlo latéritique (figure-2).

La zone sud (départements de Goudiry et Bakel) est située dans la région de Tambacounda, dans la zone éco géographique agro-sylvopastorale centre Est et Sud Est, précisément dans la sous-zone sylvopastorale (figure-2).

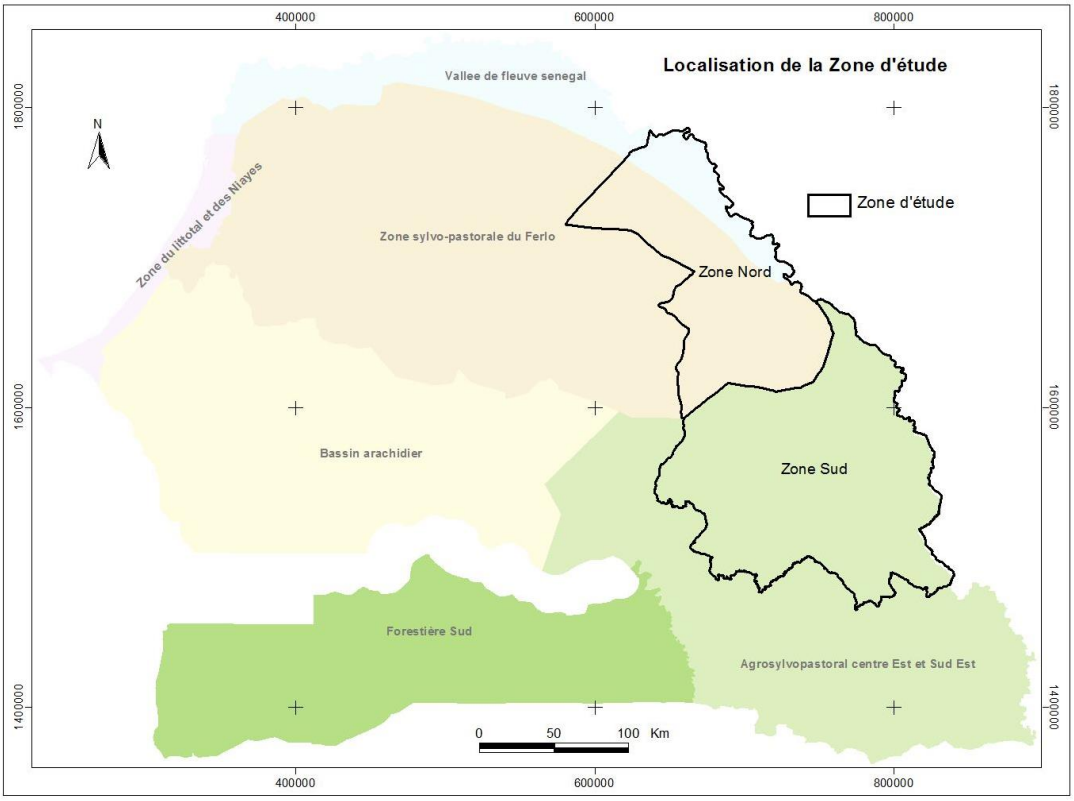

Figure-2 : situation éco-géographique de la zone d'étude (source CSE)

II-1- Sol

La partie nord est caractérisée par un relief relativement plat par rapport au reste du pays, constitué par une vaste plaine incisée de vallées (figure-3). Cette partie est caractérisée par des Lithosols qui sont en grande partie inaptes à l'agriculture (INP, 2008 ; Fall et Diagne, 2010). C'est une zone très touchée par l'érosion éolienne qui fragilise la couche arable, contribuant ainsi à la dégradation de la structure du sol et à la diminution de sa fertilité (Fall, 2002). L'érosion hydrique y est également élevée.

Dans la zone sud, on rencontre aussi des Lithosols qui sont comme pour la zone nord pour une grande majorité inaptes à l'agriculture (INP, 2008 ; Fall et Diagne, 2010). L'érosion éolienne est de faible ampleur dans cette zone du fait de la topographie du terrain. Par contre l'érosion hydrique est très élevée. Cette érosion a pour effet, de détruire les infrastructures (routes et ponts) et les habitations.

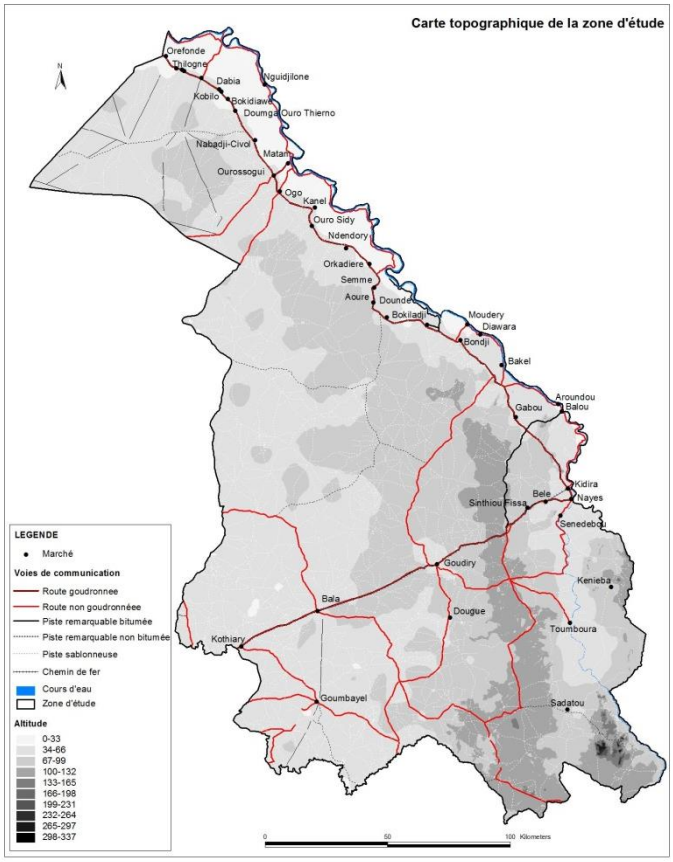

Figure-3: Carte topographique montrant les altitudes, avec les voies de communication (source base de données CSE)

II-2- Végétation

Au Sénégal, la végétation est intimement liée à la distribution de la pluviométrie. La partie nord de notre zone d'étude est constituée principalement d'une savane arbustive composée principalement de *Combretumglutinosum, Combretumnigricans, Bombax costatum,Sterculiasetigera, Acacia macrostachya*et le *Sterocarpuscrineceus.* Tandis qu'au sud on rencontre une savane boisée, on y rencontre souvent *Combretumglutinosum, Belanitesaegyptiaca, Acacia tortilis, ziziphusmauritiana, Acacia tortilis*et *l'Acacia senegalensis*. Tout au long de la vallée, on a une steppe arbustive (CSE, 2005). La production annuelle de biomasse suit un gradient nord sud. D'une moyenne 400 Kg.MS/ha au nord, on passe à plus 4000 Kg.MS/ha aux sud.

II-3- Climat

La zone d'étude présente les principaux traits du climat sahélien et nord-soudanien à savoir : des précipitations annuelles comprises entre 400 et 1000 mm, associées à une forte variabilité spatio-temporelle, des températures élevées induisant une forte demande évaporative et une précarité des réserves en eau souterraine (Leroux, 1980 ; Le Houérou, 1989 ; Ndione, 2002). Quel que soit le domaine climatique (sahélien et nord-soudanien) considéré, il est caractérisé par deux saisons bien distinctes : une saison sèche qu'il s'étale d'octobre à mai et une saison des pluies de mai à octobre caractérisée un gradient nord-sud de la pluviométrie.

II-4- Ressources hydriques

La partie orientale du Sénégal dispose d'un potentiel en ressources hydriques composées par : les eaux pluviales, les eaux de surface et les eaux souterraines.

- les **eaux pluviales** ont une forte composante temporelle et sont fortement liées aux précipitations. Les pluies sont concentrées sur quatre à cinq mois avec des variations spatiales allant de plus de 700 mm au sud de la zone à 400 mm au nord. Ces eaux contribuent à la recharge des nappes d'une part et d'autre part à l'alimentation des cours d'eau et des mares.

- les **eaux de surface** sont constituées principalement de mares non pérennes.

- les **eaux souterraines** sont représentées par les quatre groupes d'aquifères : le système aquifère superficiel, le système intermédiaire, le système aquifère profond et les aquifères du socle. Elles permettent la satisfaction des besoins en eau là où les eaux de surface font défaut (en qualité et en quantité). Le maestrichien est exploité par **840 forages d'après la Direction de l'hydraulique**, à raison de 205 000 m^3 par jour, pour l'approvisionnement en eau des populations rurales et du cheptel. Il représente une réserve de 350 milliards de mètres cubes dont le cœur se trouve au centre du **Ferlo**. Les eaux souterraines connaissent beaucoup de contraintes liées surtout à la profondeur des nappes, à leur très forte minéralisation ainsi que la surexploitation de certaines nappes.

En somme, cette zone appartient à la bande sahélienne et ses ressources en eau sont fortement tributaires des conditions pluviométriques.

II-5- Elevage

L'essentiel du cheptel de la zone d'étude est constitué de bovins Djakoré, zébus Gobras et taurins Ndama dans sa partie Sud vers Bakel et Goudiry tandis qu'au Nord de la zone on rencontre surtout des Gobras. De grands troupeaux de petits ruminants font de plus en plus leur apparition dans la zone. Les asins et les équins augmentent en raison de leur importance grandissante dans la corvée d'eau.

La conduite des animaux est fortement influencée par le rythme des saisons. Il s'agit d'un élevage de type traditionnel, extensif dans la partie Sud. Par contre, la zone Nord est caractérisée par un élevage extensif transhumant.

L'exploitation des parcours naturels est organisée autour des points d'eau : mares temporaires en hivernage (saison des pluies) et forages ou puits en saison sèche. La recherche d'eau et de pâturages entraîne le déplacement fréquent des troupeaux autour des points d'eau de saison sèche (forages). Ces déplacements conditionnent le type d'habitat des pasteurs. Les animaux dépendent entièrement de la disponibilité du fourrage dans les jachères, les parcours naturels (forêts) et les résidus des cultures dans les champs en saison sèche pour leur alimentation. Malheureusement ce potentiel fourrager est souvent anéanti par les feux de brousse.

La complémentation alimentaire se fait uniquement en saison sèche. Elle cible une partie du troupeau communément appelée noyau sensible. Il s'agit principalement des individus faibles (laitières, animaux âgés ou malades). Néanmoins, quelques difficultés liées à l'approvisionnement et au coût très élevé limitent cette complémentation alimentaire (tourteau du Mali, aliments concentrés du Sénégal et graines de coton).

II-6- Agriculture

L'agriculture y est vivrière et est strictement pluviale avec les spéculations de riz, mil, sorgho, niébé, arachide pour l'essentiel. Dans la partie nord elle est principalement pratiquée dans les localités qui jalonnent la route nationale (AVGSAN, 2010).

III- Matériel et Méthodologie

III-1- Méthodologie

Ce travail de modélisation, utilise les données climatiques pour estimer la production biomasse et les ressources en eau. La production de biomasse est estimée à partir du modèle STEP, qui est un modèle mathématique développé et validé sur l'ensemble de la bande sahélienne. La production de biomasse estimée est ensuite utilisée pour le calcul de la capacité de charge. La modélisation des ressources consiste à estimer la durée d'ennoiement des mares à partir des données climatiques. Le fourrage post-récolte, est quand lui calculé par l'ISRA.

III-1-1- Modélisation de la biomasse

Pour mener cette étude, le modèle STEP (***S****ahelian****T****ranspiration****E****vaporation and* ***P****roduction model*) a été utilisé. Il s'agit d'un modèle de fonctionnement qui permet de simuler la dynamique de croissance de la végétation herbacée sahélienne et des variations de l'état hydrique du sol à un pas de temps journalier (Mougin*et al.*,1995a ; figure-4). Comme l'indique la figure-3, ce modèle mathématique, calcule tous les paramètres de croissance de la végétation à partir des données climatiques et de texture du sol.

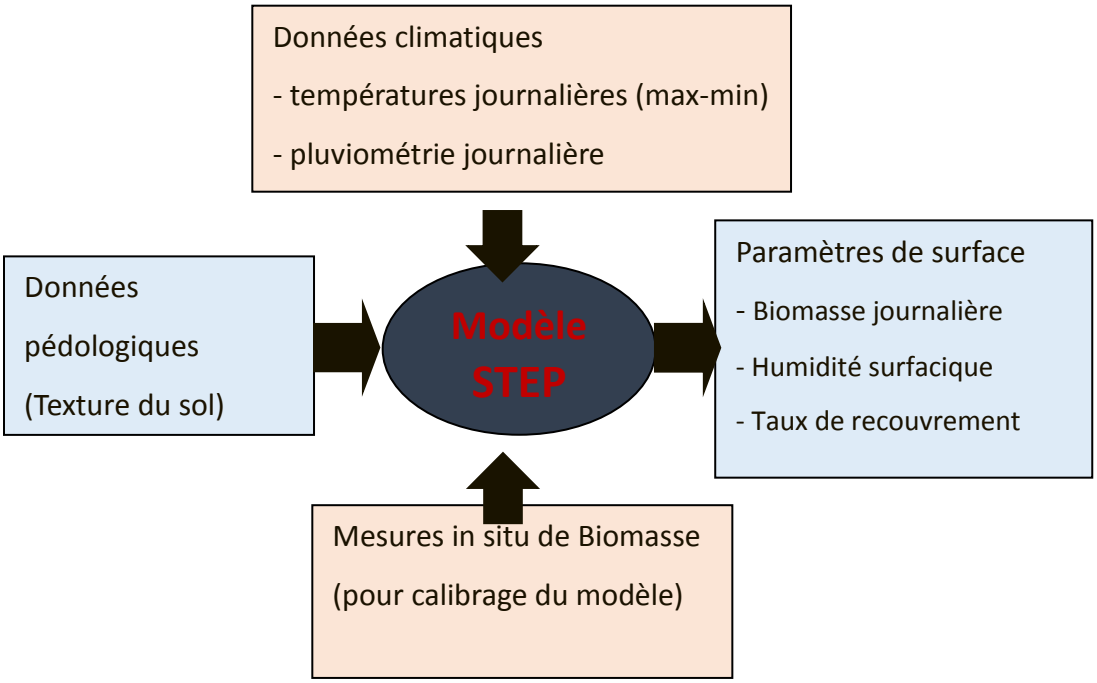

Figure 4: Schéma de fonctionnement du modèle STEP, représentation des principaux inputs et les outputs.

Les données d'entrées :

Les variables d'entrée de ce modèle sont la pluviométrie journalière, les températures maximales et minimales journalières, la composition minéralogique du sol (pourcentage sol argile). Pour la calibration du modèle, les données historiques issues des cartes de biomasse du CSE seront utilisées. Pour mieux contextualité l'étude, les données climatiques historiques ont été simulées sur des années sèches, normales et humides. Cela pour mieux prendre en compte la variabilité interannuelle du climat. Après calibrage, les données de prévision climatiques sont utilisées comme *input* pour estimer la production végétale. Pour rappel, ce modèle est déjà paramétré pour le Ferlo (Faye., 2013).

L'un des problèmes majeurs pour l'utilisation de ce modèle réside sur la disponibilité des données climatiques journalières et des données historiques de biomasse pour sa calibration. Toutefois, le CSE dispose d'une base de données sur la production annuelle de biomasse depuis 1987.

III-1-2- Modélisation du fourrage post-récolte

Cette partie a été faite par l'ISRA qui nous a fourni les rendements pour 2030 et 2050. Nous avons par la suite calculé les sous-produits agricoles qui constituent une source de nourriture non négligeable pour le bétail.

Les quantités de sous-produits disponibles (pâturages post récolte, fanes d'arachide et de niébé) seront obtenues en utilisant l'approche élaborée par l'ISRA (Fallet al. 1989) qui combine

les rendements, le coefficient de conversion (rapport paille grain), le coefficient d'utilisation (biomasse disponible par rapport à la biomasse totale) et le taux de matière sèche.

- La quantité de sous-produits agricoles disponible pour le bétail est donnée par la formule suivante :

Paille = Grain *K*0,6*%MS

Grain : rendement agricole

K est le coefficient de conversion, il est égal à :

- **1,5 pour le riz, le maïs et l'arachide;**
- **7,5 pour le mil et le sorgho;**
- **6 pour le niébé).**

0,6 *est le coefficient d'utilisation (en effet, les quantités de sous-produits disponibles correspondent à 60% de la biomasse totale)*

% MS *est le taux de Matière Sèche qui est en moyenne égal à 87 % pour les pailles.*

Capacité de charge :

Une fois la production de fourrage calculée, nous la transformons en capacité de charge qui représente le nombre d'animaux (exprimé en UBT) que peut supporter le pâturage sans se dégrader tout en leur permettant d'assurer leurs besoins d'entretien voire de production. Le besoins en alimentation bétail est calculé à partir du besoin journalier qui est 6.25 kg.MS par jour/UBT. Pour le besoin annuel (saison sèche), dans la partie nord la saison sèche (entre la fin de croissance de la végétation et l'arrivée des pluies de la saison suivante) est de 9 mois contre 8 pour le sud.

Zone nord : Capacité de charge = Biomasse disponible de la zone / (6.25 * 270)

Zone sud : Capacité de charge = Biomasse disponible de la zone / (6.25 * 240)

La biomasse disponible est le 1/3 de la biomasse herbacée totale. Les 2/3 représentent les pertes divers (piétinements, fécès, feux de brousse, etc.), la biomasse non accessible ou de qualité non appétée, ou la biomasse de protection du sol contre l'érosion etc. la capacité de charge est ensuite confronté à la population animale présente dans la zone (exprimé en UBT). Ce qui permet de voir si la biomasse produite sera suffisante pour nourrir tout le bétail ou pas.

III-1-3- Modélisation des ressources hydriques

Elle porte essentiellement sur les mares qui constituent encore une source d'eau importante pour les populations pastorales de la zone (eau de boisson en saison des pluies et abreuvement du bétail jusqu'au tarissement). Seules les mares les plus importantes c'est-à-dire qui conservent l'eau jusqu'en décembre au moins et par conséquent contribuent fortement à l'abreuvement du cheptel en saison sèche, sont considérées. Ces données sont obtenues sur la base d'une enquête auprès des responsables départementaux d'élevage ainsi que les PLD récents. Le paramètre suivi est la durée d'ennoiement des mares qu'on a appelé DEM. La localisation géographique des six mares les plus importantes considérées dans cette étude est donnée dans la Figure-5 ci-dessous.

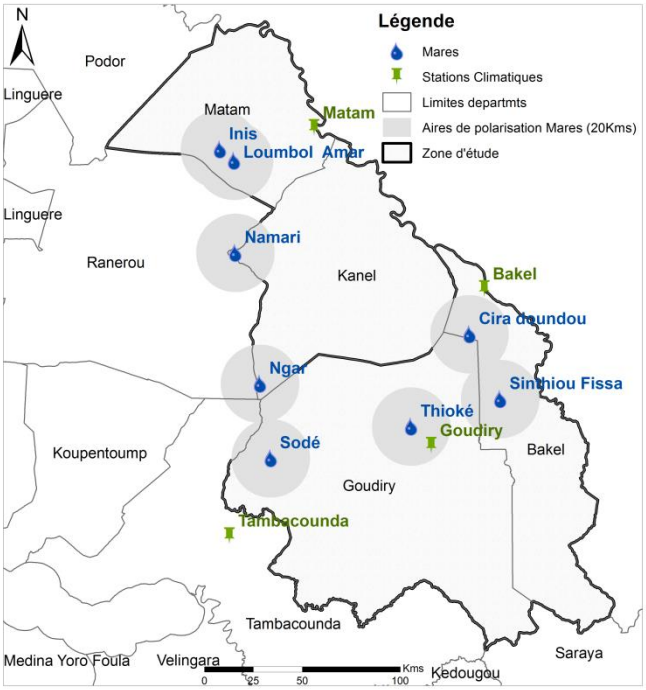

Figure 5 : Localisation des mares les plus importantes et les stations pluviométrique au sol de l'ANACIM.

La relation entre la durée d'ennoiement et les variables climatiques est analysée afin de créer des modèles de prédiction du comportement des mares à l'horizon 2030 et 2050 pour les différents scénarios climatiques. Les variables climatiques considérées et qui sont susceptibles d'expliquer la DEM sont les suivantes : le cumul annuel de la pluie (Cump), température moyenne annuelle (Tmoy), température minimale moyenne annuelle (Tmin), et la température maximale moyenne annuelle (Tmax). Compte tenu du chevauchement de la saison sèche sur deux années successives (les mares d'une année données sont remplies par les pluies de l'année X-1). Pour chaque mare, les données de la station climatique la plus proche sont utilisées (Tableau-1).

Tableau-1 : les mares les plus importantes et station climatique la plus proche.

Mare	Station climatique associée
Loumbolamar	Matam
Inis	Matam
Namari	Matam
Ngar	Tambacounda
Sodé	Tambacounda
Thioké	Goudiry
Sinthiou Fissa	Goudiry
Cirdoundou	Bakel

Pour chaque mare, on cherche le ou les paramètres climatiques (Pluie, Tmoy, Tmin et Tmax) qui expliquent le mieux sa durée d'ennoiement. Une régression multiple entre la Durée

d'Ennoiement des Mares (variables expliquées) et les variables climatiques considérées listées plus haut (variables explicatives) sera fait.

Pour l'évaluation des modèles, les critères retenus sont le test F de Fischer, le coefficient de détermination ajusté (R^2 ajusté). Le F de Fischer est un test statistique qui permet d'apprécier la signification globale d'un modèle (Confais et Le Guen, 2006), sur la base du rapport entre les variances expliquées et celles inexpliquées. Le meilleur modèle étant celui qui présente le test F le plus élevé (et significatif au seuil de 0,05), le R^2 le plus proche de 1 pour une mare donnée.

III-2- Données

III-2-1- Climatiques

Pour faire ce travail, des données historiques ont été utilisées pour calibrer les modèles d'une part, et d'autre part pour étudier la variabilité de la production annuelle de biomasse. Les données de projection, sont utilisées pour prédire la production de biomasse à l'horizon 2030 et 2050. Elles ont été fournies par Tetratech qui était chargé de choisir les six années historiques dont 2 sèches (1984 et 1992), deux normales (1987 et 1998) et deux humides (1988 et 1994).

Pour les besoins de l'analyse du comportement des mares, nous avons acquis les données climatiques (pluviométrie et température) mesurées au sol auprès de l'ANACIM. Il s'agit des données des stations de Matam, Bakel, Goudiry et Tambacounda pour les années 2009 à 2013 correspondant à la période ou nous avons les informations sur les mares. Ces données historiques sont utilisées pour chercher des modèles de prédiction de la durée d'ennoiement des mares.

III-2-2- Biomasse herbacée

Les données de biomasse utilisées pour calibrer le modèle STEP sont issues de la base de données du CSE. En effet, pour bien suivre la biomasse, le Centre de Suivi Ecologique a implanté sur l'ensemble du territoire national des sites de contrôle au sol. A la fin de chaque saison des pluies, des équipes procèdent à une campagne d'échantillonnage de la production primaire. Le but de cette campagne est de calibrer le NDVI (Indice de Végétation par la Différence Normalisée) afin de pouvoir simuler la production de biomasse sur l'ensemble du territoire à partir des images NDVI de NOAA (1987-1999) puis de SPOT Végétation (2000 à nos jours). Ainsi, chaque année une carte de la production primaire (kg.MS/ha) à un kilomètre de résolution est produite sur l'ensemble du territoire national.

Pour calibrer notre modèle, nous avons extrait de ces cartes historiques, la production herbacée annuelle d'une sous zone de 3x3 km autour des stations de pluies. Ce choix correspond à l'envergure d'un site de collecte de biomasse.

III-2-3- Les données sur le cheptel

Les données du cheptel utilisées dans ce travail (population actuelle du cheptel ainsi que les taux de croît des 20 dernières années) ont été obtenues auprès de la Direction de l'Elevage du Sénégal. A partir de ces données, le taux croît moyen du cheptel est calculé, ce qui a permis par la suite d'estimer le cheptel à l'horizon 2030 et 2050. Il sera ensuite question de déterminer le

besoin fourrager (biomasse herbacée et biomasse post-récolte) pour les années à venir, ce qui permettra d'estimer la vulnérabilité du cheptel.

III-2-4- Les données sur les ressources hydriques

Cette zone étant à dominante pastorale qui utilise prioritairement les mares comme source d'abreuvement, il est question pour nous de mieux comprendre le comportement des mares à l'horizon 2030 et 2050. Le tableau-2 donne les caractéristiques des cinq mares les plus importantes.

Tableau-2 : Mares importantes au niveau de la zone d'étude

Communauté rurale	Mares	Coordonnées (X;Y)	Villages polarisés	Utilisation (cheptel en UBT)	Observations
Ndendory	Ngar	659229 ; 1600985	Ngar, Toubelbali, ToubéréAmadou, ToubéKaé, Toubédiaobé et Wourogorel, Gassabé	4200	Beaucoup de transhumants
Wouro sidi	Namari	646689 ; 1667907	Namari, Oudalaye, Fétéfowrou, Naikimango et Naikitokosel, Louguérémbaba, Malandou	3090	Beaucoup de transhumants
Ogo	Loumbol Amar	645975 ; 1714978	Loumbolamar, Patouki, Lambago, Inis, Mbélone, Loumbolalouki, Loumbol samba alpha, Mbinguelsamody, Bokidiawé, Ndoulougou.	6780	
Ogo	Inis	638784; 1720802	Inis, Loumbolamar, Patouki, Lambago, Mbélone, Loumbolalouki, Loumbol samba alpha, Mbinguelsamody, Mbéba, Karayal	3230	Plus les troupeaux transhumants de Mauritanie
Sinthiou fissa	Sinthiou Fissa	781894 ; 1593189	Sinthiou fissa, Séoudji, Yuppépathé, Goureldongobé (Sinthiouseydoundoula), Banitelli, Kippusoulèye (Dyabougou mossi)	2416	Beaucoup de transhumants en transit
Gabou	Cira doundou	766207 ; 1626294	Sirademboye, Sirabaydi, Sirasissibe, Samba konté, Senosimbing	1245	Forte utilisation de l'eau pour le maraîchage
Koulor	Sodé	664743 ; 1562879	Sodé, Kaldeme, Dambamba, DiamwellyDiallo, Madina 2, SinthiouKafafi, SinthiounibaDemba,	3360	

Communauté rurale	Mares	Coordonnées (X;Y)	Villages polarisés	Utilisation (cheptel en UBT)	Observations
			SinthiouHamath Ali		
Sinthiou Mamadou Boubou	Thioké	736452 ; 1579115	Thioké, SinthiouIdy, Wourokaba, Mbailadji, Thiaski, SinthiouBodel, Wourogoumbo	2250	Mare aménagée par le projet USAID

Pour étudier le comportement des mares dans les prochaines années, nous avons utilisé les données sur la durée d'ennoiement des grandes mares de la zone d'étude au cours des cinq dernières années pour le calibrage du modèle sur les ressources hydriques. Ces données sont obtenues sur la base d'une enquête auprès des responsables départementaux d'élevage ainsi que les PLD récents comme présenté dans Tableau-3 ci-dessous. Pour avoir la durée d'ennoiement en nombre de mois, le décompte a été fait à partir du mois de novembre de chaque année.

Tableau-3 : Mois de tarissement des mares les plus importantes de la zone d'étude au cours des 5 dernières années

Mare	2013	2012	2011	2010	2009
Loumbolamar	Mai	Mai	Avril	Avril	Avril
Ngar	Avril	Février	Mars - Avril	Mars -Avril	Mars
Inis	Avril	Avril	Mars	Mars	Mars
Namari	Avril	Février	Mars	Mars	Mars
Sinthiou Fissa	Mars	Mars	Avril	Mars	Mars
Cirdoundou	Avril	Avril	Mars	Avril	Avril
Sodé	Mai	Mai	Avril	Mai	Mai
Thioké	Avril	Avril	Mars	Avril	Avril

A l'épuisement des mares, les éleveurs se rabattent sur les forages qui sont disponibles dans la zone. Ce qui entraine une charge importante autour de ces points d'eau. Les données sur les forages sont également nécessaires pour déterminer le fourrage accessible au bétail. En effet, les éleveurs sont obligés de rester autour des points d'eau durant la saison sèche pour l'abreuvement de leurs troupeaux. La zone de desserte optimale d'un forage est inférieure ou égale à 20 km.

Les données sur les points d'eau sont obtenues auprès de la Direction de l'Hydraulique.

III-2-5- Les données sur les rendements agricoles

La modélisation des rendements agricole a été effectuée par l'ISRA.

IV Résultats et discussions

IV-1- La production de biomasse en 2030 et 2050

- **analyse de la différence entre les mesures et les simulations**

Une exploitation de l'historique montre une bonne corrélation entre la biomasse simulée par le modèle et celle du CSE avec un R^2 de 78 % (figure-6). Cela nous permet de s'assurer que le modèle a bien été calibré.

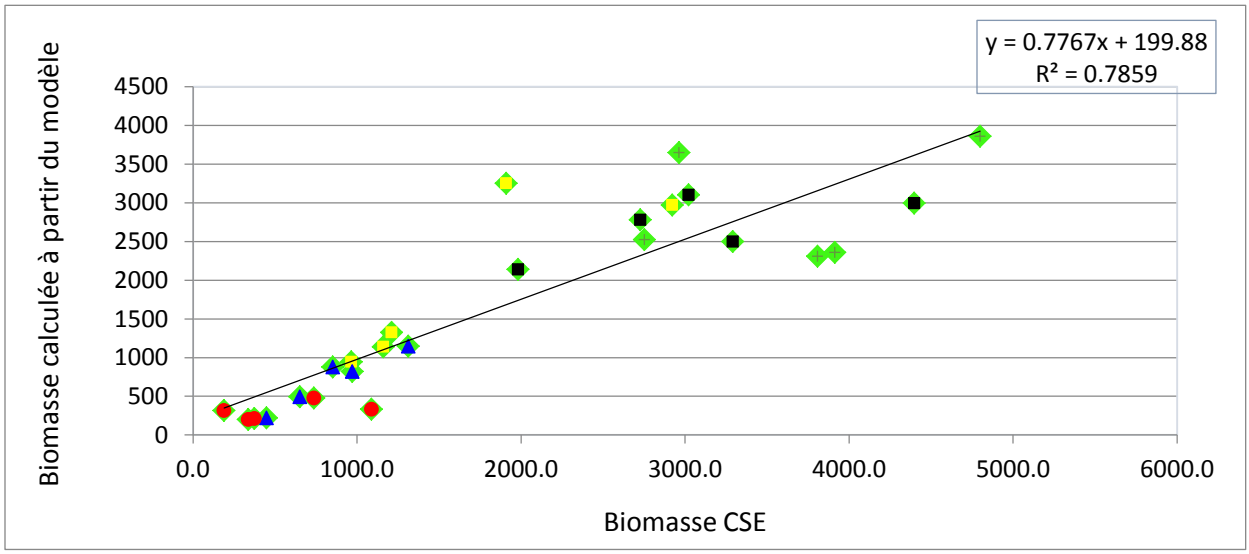

Figure-6 : corrélation entre les productions annuelles de biomasse mesurées par CSE et celles simulées par le modèle. La courbe de tendance est celle de toutes les données réunis. Cercle rouge (Podor), triangle bleu (Matam), carré jaune (Bakel), étoile noire (Goudiry) et croix marron (Tamba).

Néanmoins, l''écart observé entre les mesures et les simulations est un biais qui doit être corrigé sur les projections. Cela afin de pouvoir comparer les projections avec les mesures historiques du CSE. Pour cette raison, nous avons calculé l'écart relatif moyen entre les mesures du CSE et les simulations pour chaque site (Tableau-3).

On constate qu'en moyenne le modèle surestime la production de biomasse pour les sites de Bakel de +10.0%, contrairement aux sites de Goudiry (-12.5%), Podor (-11.9%) et surtout Matam et Tambacounda ou le modèle sous-estime la production d'un plus de 24% (tableau-4).

Ces écarts en pourcentage sont ensuite utilisés pour faire les corrections des simulations. L'écart relatif entre les résultats du modèle et la biomasse du CSE diffère selon que l'année soit humide, normale ou sec, il était préférable de calculer l'écart relatif moyen par site et par année (humide, normal et sec). Mai cela risque de trop biaiser les calculs du fait qu'on n'a pas assez de données notamment les années sèches ou on a les données pour une seule année (1992). Ainsi nous avons opté de calculer un écart relatif moyen par site.

Tableau-4 : comparaison entre les productions annuelles de biomasse mesurées par le CSE et les résultats de la modélisation.

Sites	Type d'année	Biomasse moyenne historique (CSE)	Biomasse moyenne historique (modèle)	Ecart relatif moyen par site (%)
Bakel	Année sèche (1992)	964.9	942,4	10.1
	Année normal (moyenne 1987, 1998)	1186.0	1231,3	
	Année humide (moyenne 1988, 1994)	2416.0	3110,4	
Goudiry	Année sèche (1992)	3291.4	2495,8	-12.5
	Année normal(moyenne 1987, 1998)	2354.9	2459,4	
	Année humide (moyenne 1988, 1994)	3709.9	3047,4	
Matam	Année sèche (1992)	447.9	217,9	-24.9
	Année normal(moyenne 1987, 1998)	752.0	683,9	
	Année humide (moyenne 1988, 1994)	1143.1	980,0	
Podor	Année sèche (1992)	189.5	312,1	-11.9
	Année normal(moyenne 1987, 1998)	537.5	335,8	
	Année humide (moyenne 1988, 1994)	732.5	271,0	
Tambacounda	Année sèche (1992)	3808.4	2305,9	-24.2
	Année normal(moyenne 1987, 1998)	3333.3	2440,8	
	Année humide (moyenne 1988, 1994)	4091.5	3751,0	

- **variation par rapport à la moyenne normale simulée pour chaque zone**

Pour chaque zone on a calculé la production simulée moyenne en année normale (moyenne des simulations des années 1987, 1998). La figure-7 donne une distribution par rapport à la moyenne des années considérées comme normales pour chaque site. On constate un important écart entre les années normales et les années humide surtout pour les sites de Bakel et Tambacounda et dans une moindre mesure celui de Goudiry. Ces sites se trouvent dans la zone sud, ce qui nous donne une idée la sensibilité dans cette zone.

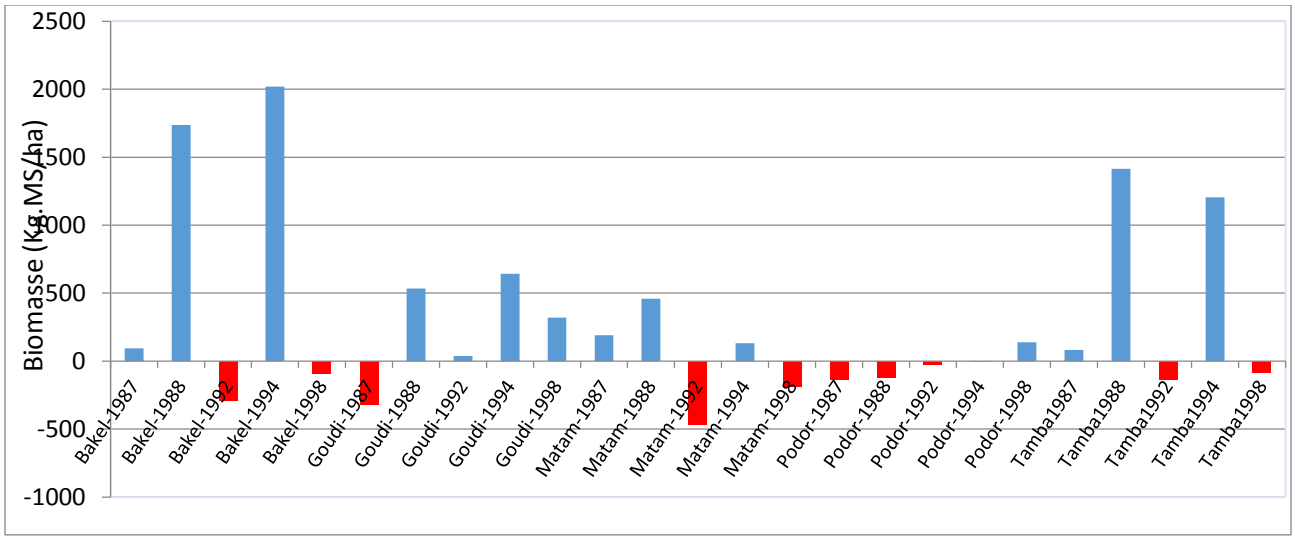

Figure-7 : présentation de la variabilité de la production herbacée par rapport à la moyenne des deux années considérées comme normales (1987, 1998).

- **correction du biais sur les projections.**

Compte tenu de l'écart noté entre les mesures et les simulations, nous avons jugé nécessaire d'appliquer une correction sur les projections (simulées) afin de pouvoir les comparer avec la biomasse historique mesures par le CSE (résultats présentés dans le Tableau-4).

Les écarts relatifs entre les projections corrigées et les référence historiques du CSE on été présenté dans le tableau-5. En effet, pour les années sèches la référence est la production de biomasse du CSE de 1992, pour les années normales la référence est la moyenne de la production du CSE des années 1987, 1998 et les années humides c'est la moyenne de la production de biomasse du CSE des années 1988, 1994. Ces écarts relatifs seront ensuite spatialisés pour être appliqués sur les cartes de biomasse du CSE des même années afin d'obtenir les cartes de biomasse projetées pour les trois types de modèles pour 2030 et 2050 (fig. 8, 9,10). L'année de référence pour cette étude est la moyenne 1987, 1998, car étant les années qui ont des pluviométries dites normales. Mais pour spatialiser nos résultats, on a fait recours aux cartes de biomasse du CSE. Donc chaque projection est comparée à l'année correspondante (humide, normale et sèche).

Tableau-5 : écart entre les productions annuelles de biomasse projetée et les biomasses mesurées des années de références.

Sites	années	Modèle	Biomasse projetée avant correction (modèle)	Biomasse projetée corrigée (modèle)	Ecart relatif moyen (%)
Bakel	2030	Dry	1048,1	952,0	-1,3
		Normal	1251,4	1136.6	-4.2
		wet	2835,1	2575,0	+6,6
	2050	Dry	997,2	905.7	-6.1
		Normal	1072,6	974,2	-17,9
		wet	3089,7	2806.3	+16.2

Goudiry	2030	Dry	2109,1	2410,4	-26,8
		Normal	2759,8	3154.1	+33.9
		wet	2953,6	3375,5	-9,0
	2050	Dry	1873,6	2141.3	-34.9
		Normal	1721,5	1967,4	-16,5
		wet	2871,4	3281.6	-11.5
Matam	2030	Dry	341,8	455,1	+1,6
		Normal	571,2	760.6	+1.1
		wet	618,3	823,3	-28,0
	2050	Dry	291,6	388.3	-13.3
		Normal	583,9	777,5	+3,4
		wet	609,7	811.9	-29
Podor	2030	Dry	278,5	316,1	+66,8
		Normal	217,2	246.5	-54.1
		wet	394,5	447,8	-38,9
	2050	Dry	245,1	278.2	+46.8
		Normal	335,7	381,0	-29,1
		wet	305,1	346.3	-52.7
Tambacounda	2030	Dry	2190,5	2889,8	-24,1
		Normal	2136,1	2818.1	-15.5
		wet	2763,2	3645,4	-10,9
	2050	Dry	2398,1	3163.7	-18.5
		Normal	2649,1	3494,9	+4,8
		wet	3759,5	4959.8	+27.8

- **Production projetée de biomasse**

Les figures-8, 9 et 10 montrent une nette tendance à la baisse de la production herbacée à l'horizon 2030 et 2050. Le tableau-6 donne un récapitulatif des différentes productions par zone.

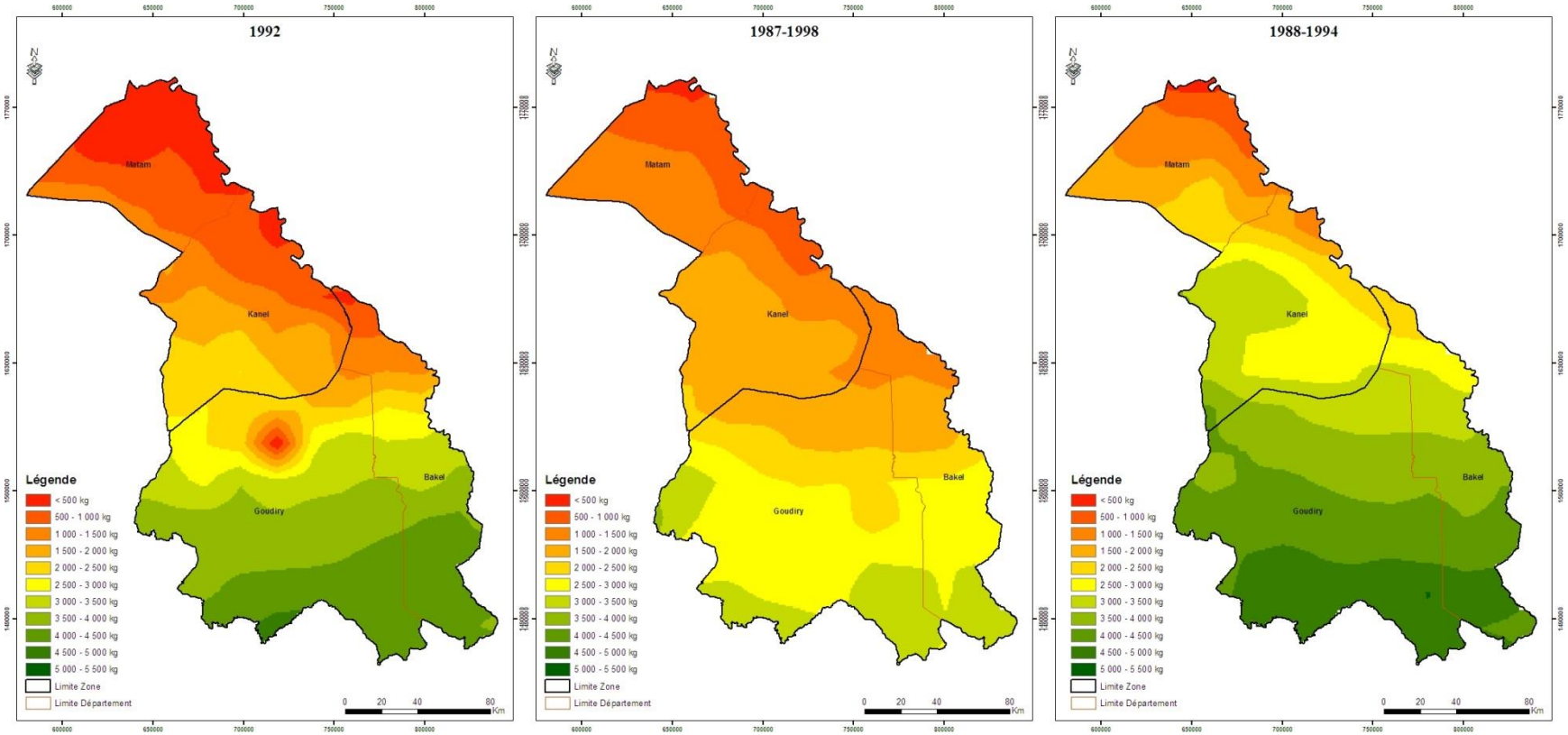

Figure-8 : Carte de biomasse observée durant une période sèche (1992), normale (1987,1998) et humide (1988, 1994).

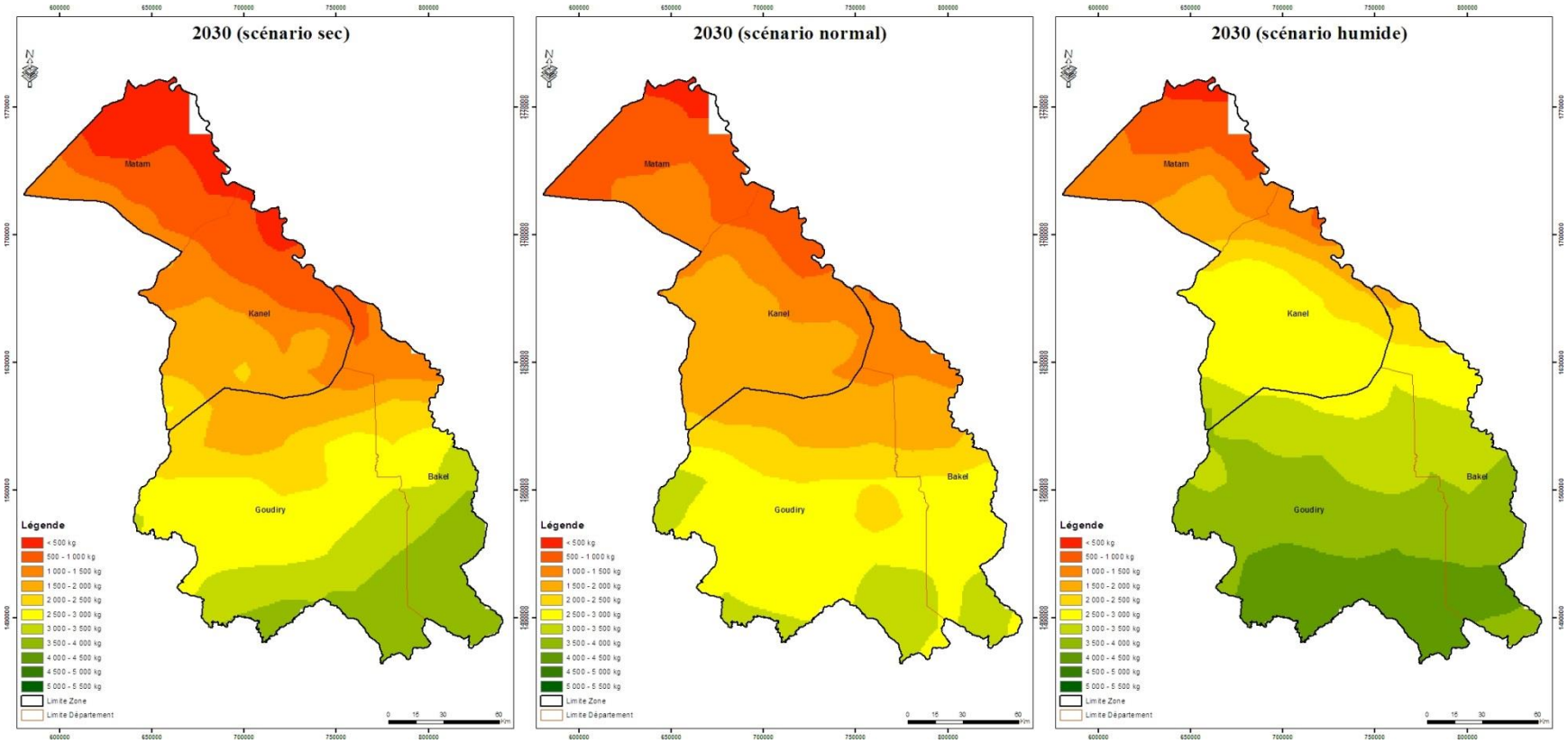

Figure-9 : Carte de biomasse projetée pour 2030 (modèle sèche, normale et humide).

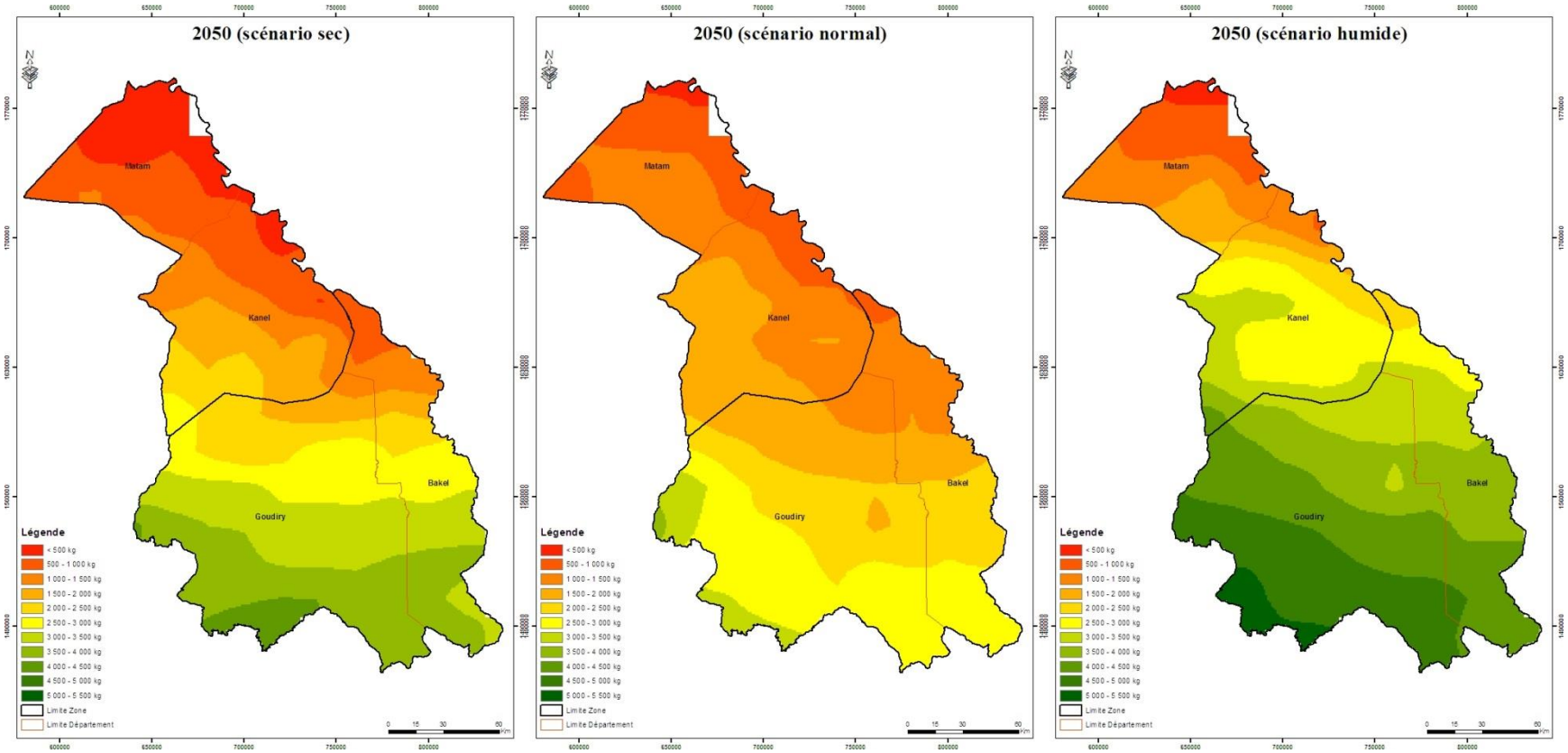

Figure-10 : Carte de biomasse projetée pour 2050 (modèle sèche, normale et humide).

Etant donnée le problème d'accès à l'eau dans la zone, nous avons calculé la production totale et celle dite accessible. La biomasse accessible se situe dans les zones se trouvant à moins de 20 km d'un point d'eau (figure-11). Ces différents points d'eau ont été obtenus auprès de la direction de la DGPRE (Direction Générale de la Planification des Ressources en Eaux). Le Tableau-5 donne les différentes productions.

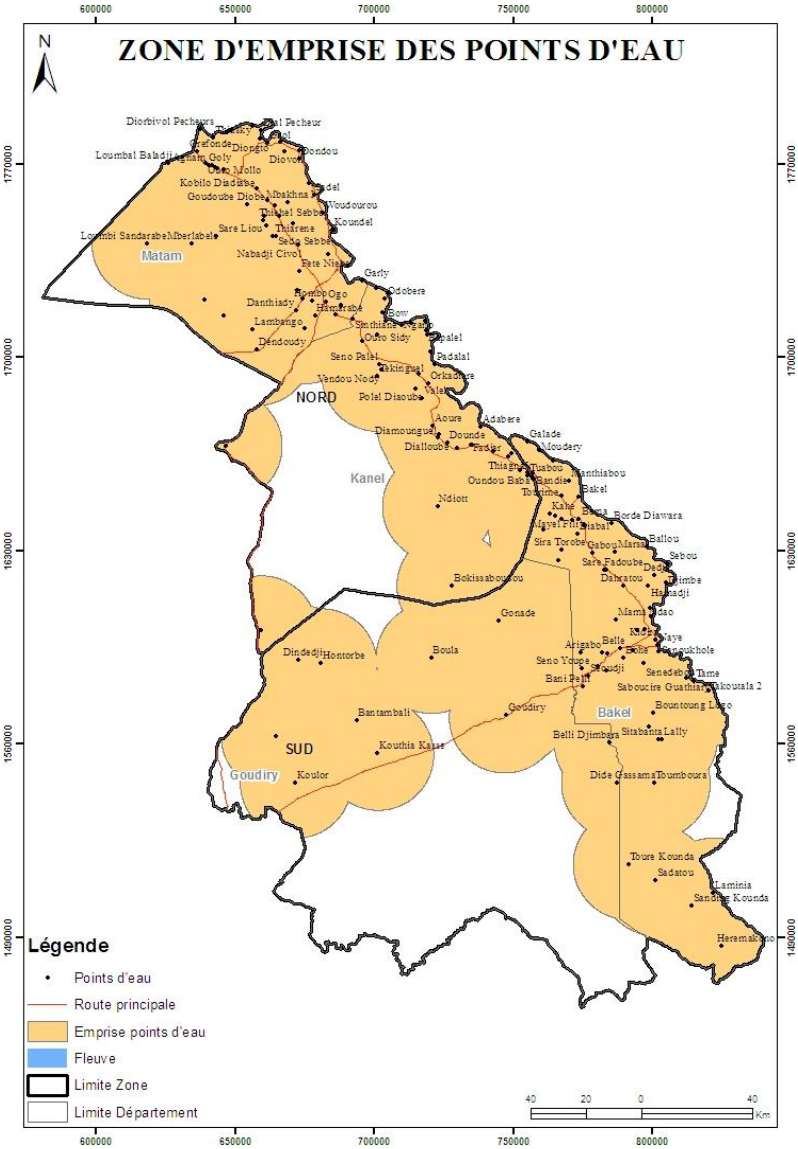

Figure-11 : zones d'emprise des points d'eau (zone à moins de 20 km d'un point d'eau)

Tableau-6 : Biomasse totale et celle accessible par zone.

		Biomasse Totale				Biomasse accessible		
		référence	2030	2050		référence	2030	2050
Zone nord	sèche	1 901 347.1	1 495 462.0	1 509 182.8		1 247 003.4	949 649.6	939 194.9
	Normale	2 082 337.5	1 717 274.9	1 714 047.1		1 495 103.4	1 178 764.1	1 193 457.5
	Humide	3 757912.6	2 451 098.6	2 944 339.4		2 691 241.2	1 892 743.7	2 000 529.9
Zone sud	sèche	7 636 054.0	6 016 285.1	6 519 693.0		4 807 473.0	3 819 514.5	4 024 427.9
	Normale	5 745 821.8	5 416 031.6	4 893 846.9		3 693 361.1	3 473 854.8	3 077 711.2
	Humide	9 255 080.5	7 911 376.3	8 909 624.3		6 035 295.1	5 146 551.2	5 719 099.9

Compte tenu du manque de données de projection du cheptel, nous avons utilisé la moyenne du taux de croît des 20 dernière année pour calculer un taux de croît moyenne annuel qu'on a appliqué pour les années à venir. Une analyse des taux de croît annuel des 20 dernières années, fournis par la Direction de l'Elevage, nous a permis d'obtenir le taux moyen annuel d'évolution des différents espèces herbivores élevées au Sénégal : 1.1% pour le bovin, 2.5% pour les petits ruminants (ovins et caprins) et 1.3% pour les équidés (équins et asins).

Le tableau-7 donne un récapitulatif du cheptel actuel ainsi que celui projeté pour 2030 et 2050 et son équivalent en UBT (Unité de Bétail Tropical). Le besoins en alimentation bétail est calculé à partir du besoin journalier qui est 6.25 kg.MS par jour/UBT. Pour le besoin annuel (saison sèche), dans la partie nord la saison sèche (entre la fin de croissance de la végétation et l'arrivée des pluies de la saison suivante) est de 9 mois contre 8 pour le sud. Ce qui donne :

Besoin alimentaire en saison sèche = Nbre d'UBT * 6.25 * 270 (pour la zone nord)

Besoin alimentaire en saison sèche = Nbre d'UBT * 6.25 * 240 (pour la zone sud)

Les transhumants ne sont pas pris en compte (transhumance interne et transhumance transfrontalière) alors qu'elle occupe une place non négligeable dans cette partie du pays. La zone de Bakel est une zone de transit vers celle de Goudiry, et plus au sud encore (vers le département de Tambacounda et la région de Kédougou)

Les sous-produits agricoles ne sont pas également pris en considération. Si l'on tient compte de l'augmentation de la population en 2030-2050, on peut espérer une augmentation des superficies agricoles (peut être au détriment des pâturages) avec plus de sous-produits pour l'élevage.

Avec la diminution de la pluviométrie, on peut espérer une diminution de la pression glossinaire, une diminution de la trypanosomiase entraînant une augmentation des mouvements de bétail (bovins et petit ruminants) du Nord vers le Sud.

Tableau-7 : Evolution potentielle du cheptel dans la zone.

	Années	Bovin	Petit ruminant	Equidé	Total UBT	Besoin annuel en Tonne de matière sèche
Zone nord	2012	238 004	512 519	48233	288 238.28	**464 147.35**
	2030	289 804	799 355	59 785	373 061.08	**602 703.23**
	2050	360 685	1 309 836	75 893	503 587. 45	**816 830.72**
Zone sud	2012	237 400	225 322	10 282	215370.64	**323 055.96**
	2030	289 069	351 425	12 745	271 717.42	**407 576.12**
	2050	359 770	575 851	16 178	355 107.94	**532 661.90**

La capacité de charge potentielle, qui représente le nombre d'animaux que peut supporter le pâturage sans se dégrader tout en leur permettant d'assurer leurs besoins d'entretien voire de production, est donnée par :

Zone nord : Capacité de charge = Biomasse disponible de la zone / (6.25 * 270)

Zone sud : Capacité de charge = Biomasse disponible de la zone / (6.25 * 240)

La biomasse disponible est le 1/3 de la biomasse herbacée totale. Les 2/3 représentent les pertes diverses (piétinements, fécès, feux de brousse, etc.), la biomasse non accessible ou de qualité non appétée, ou la biomasse de protection du sol contre l'érosion etc. Ainsi, en tenant compte uniquement de la biomasse herbacée et du cheptel sédentaire, on constate que c'est seulement à l'horizon 2050 que le déficit de fourrage se fera sentir et ça seulement dans la partie nord (Tableau-8). Néanmoins un déficit au de biomasse au nord entraine une transhumance vers le sud ou la biomasse est supposée disponible. L'extension des superficies agricole peut également entrainer une diminution du disponible fourrager surtout dans la zone sud ou l'agriculture commence à gagner du terrain. Seulement nous ne disposons pas pour le moment des données nous permettant de faire des prédictions sur la transhumance ni sur l'évolution des superficies agricoles dans cette zone. Pour rappel la partie transhumance n'est pas prise en compte ici. En effet, nous n'avons pas eu de données sur la transhumance et aucun des pastoraliste consultés n'a pas d'idée sur cette question.

Tableau-8 : Disponible fourrager et différence entre ce disponible et les besoins en quantité de biomasse (unités en Tonne).

				Biomasse Totale disponible			Biomasse accessible et disponible		
		Besoin (en tonnes)		Production (en tonnes)	Taux de couverture des besoins si cheptel croissant	Taux de couverture des besoins si cheptel constant	Production	Taux de couverture des besoins si cheptel croissant	Taux de couverture des besoins si cheptel constant
Zone nord	2012	464 147.3							
			1992	633 782.4		136.5 %	415 667.8		89.5 %
			1987-1998	694 112.5		149.5 %	498 367.8		107.4 %
			1988-1994	1 252 637.5		269.9 %	897 080.4		193.3 %
	2030	**602 703.2**	sèche	498 487.3	82.7 %	107.4 %	316 549.9	52.5 %	68.2 %
			Normale	572 725.0	95 %	123.4 %	392 921.4	65.2 %	84.6 %
			Humide	817 032.9	135.6 %	176.0 %	630 914.6	104.7 %	135.9 %
	2050	**816 830.7**	sèche	503 060.9	61.6 %	108.4 %	313 065.0	38.3 %	67.4 %
			Normale	571 349.0	69.9 %	123.1 %	397 819.2	48.7 %	85.7 %
			Humide	981 446.5	120.1 %	211.5 %	666 843.3	81.6 %	143.7 %
Zone sud	2012	**323 055.9**							
			1992	2 545 351.3		787.9 %	1 602 491.0		496.0 %
			1987-1998	1 915 140.6		592.8 %	1 231 120.4		381.1 %
			1988-1994	3 085 026.8		954.9 %	2 011 765.0		622.7 %
	2030	**407 576.1**	sèche	2 005 428.4	492.0 %	620.8 %	1 273 171.5	312.4 %	394.1 %
			Normale	1 805 343.9	442.9 %	558.8 %	1 157 951.6	284.1 %	358.4 %
			Humide	2 637 125.4	647.0 %	816.3 %	1 715 517.1	420.9 %	531.0 %
	2050	**532 661.9**	sèche	2 173 231.0	407.0 %	672.7 %	1 341 476.0	251.8 %	415.2 %
			Normale	1 631 282.3	306.2 %	504.9 %	1 025 903.7	192.6 %	317.6
			Humide	2 969 874.8	557.5 %	919.3 %	1 906 366.6	357.9 %	590.1 %

IV- 2- les ressources fourragères post-récoltes

Les données sur les rendements sont fournies par l'ISRA.

Pour les superficies agricoles, nous avons utilisé les données de la direction des statistiques agricoles du Sénégal qui a la charge l'estimation des superficies agricoles et les rendements pour toutes les spéculations.

Ces résultats associés aux statistiques de la direction de l'agriculture nous a permis de faire une estimation de la production pour 2030 et 2050 (Tableau-9).

La quantité de sous-produits agricoles disponible pour le bétail est donnée par la formule suivante :

Paille = Grain *K*0,6*%MS

Grain : *rendement agricole*

K est le coefficient de conversion, il est égal à :

- **1,5 pour le riz, le maïs et l'arachide;**

- **7,5 pour le mil et le sorgho;**
- **6 pour le niébé).**

0,6 *est le coefficient d'utilisation (en effet, les quantités de sous-produits disponibles correspondent à 60% de la biomasse totale)*

*% **MS** est le taux de Matière Sèche qui est en moyenne égal à 87 % pour les pailles*

Tableau-9 : données de rendement et de superficies agricoles des deux principales spéculations de la zone pour 2012, 2030 et 2050.

			2030			2050		
			sèche	normale	humide	sèche	normale	humide
Zone nord	Maïs	Rendements (kg/ha)	948,0	815,0	2453,0	1088,0	1005,0	1575,0
		Fourrage post-récolte (kg/ha)	742,3	638,1	1920,7	851,9	786,9	1233,2
		Fourrage post-récolte total (T)	103,15	88,7	266,9	118,4	109,3	171,4
	Arachide	Rendements (kg/ha)	1300	1240	1448	1356	1322	1570
		Fourrage post-récolte (kg/ha)	1017,9	970,92	1133,784	1061,748	1035,126	1229,31
		Fourrage post-récolte total (T)	871,3	831,1	970,5	908,8	886,0	1052,2
	Sorgho	Rendements (kg/ha)	2414	2254	2870	3206	2500	3206
		Fourrage post-récolte (kg/ha)	1890,162	1764,882	2247,21	2510,298	1957,5	2510,298
		Fourrage post-récolte total (T)	14234,8	13291,3	16923,7	18905,0	14741,9	18905,0
	Mil	Rendements (kg/ha)	1493,0	1373,0	1788,0	1610,0	1548,0	2063,0
		Fourrage post-récolte (kg/ha)	1169,0	1075,1	1400,0	1260,6	1212,1	1615,3
		Fourrage post-récolte total (T)	15660,1	14401,4	18754,4	16887,3	16237,0	21638,9
	Total fourrage post-récolte zonenord…2		30869,4	28612,6	36915,6	36819,7	31974,4	41767,7
Zone sud	Maïs	Rendements (kg/ha)	1249	2162	2294	1551	1729	2408
		Fourrage post-récolte (kg/ha)	978,0	1692,5	1796,2	1214,0	1353,8	1885,1
		Fourrage post-récolte total (T)	7846,2	13578,5	14410,9	9740,2	10861,5	15123,9
	Arachide	Rendements (kg/ha)	1455	1803	1895	1505	1553	1891
		Fourrage post-récolte (kg/ha)	1139,3	1411,7	1483,8	1178,4	1216,0	1480,7
		Fourrage post-récolte total (T)	10588,3	13120,7	13790,2	10952,1	11301,4	13761,1
	Sorgho	Rendements (kg/ha)	2479	3715	3619	3032	3185	3772
		Fourrage post-récolte (kg/ha)	1940,7	2908,8	2833,7	2374,1	2493,5	2953,1
		Fourrage post-récolte total (T)	21219,2	31805,3	30983,4	25957,9	27263,5	32289,0
	Mil	Rendements (kg/ha)	1453	2377	2274	1870	2012	2390
		Fourrage post-récolte (kg/ha)	1137,7	1860,8	1780,5	1464,2	1575,0	1871,4
		Fourrage post-récolte total (T)	17277,0	28258,1	27039,3	22235,4	23918,0	28418,6
	Total fourrage post-récolte zone sud		56930,.8	86762,7	86223,9	68885,8	73344,6	89592,7

Le tableau-10 montre que l'ajout de la biomasse post-récolte ne change pas la tendance. Les années déficitaires restent toujours déficitaire. Néanmoins dans l'ensemble l'ajout du fourrage post-récolte augmente le taux de couverture d'environ 5%.

Tableau-10 : taux de couverture des besoins pour le cas ou le cheptel est croissant et le cas ou le cheptel constant (en ne considérant pas le fourrage pos-récolte et en considérant le fourrage post-récolte).

			Biomasse Totale disponible				Biomasse accessible et disponible			
			Taux de couverture des besoins si cheptel croissant		Taux de couverture des besoins si cheptel constant		Taux de couverture des besoins si cheptel croissant		Taux de couverture des besoins si cheptel constant	
			sans fourrage post récolte	avec fourrage post récolte	sans fourrage post récolte	avec fourrage post récolte	sans fourrage post récolte	avec fourrage post récolte	sans fourrage post récolte	avec fourrage post récolte
Zone nord	2030	sèche	82.7 %	87.8 %	107.4 %	114.0 %	52.5 %	57.6 %	68.2 %	74.8 %
		Normale	95 %	99.8 %	123.4 %	129.5 %	65.2 %	69.9 %	84.6 %	90.8 %
		Humide	135.6 %	141.7 %	176.0 %	180.1 %	104.7 %	110.8 %	135.9 %	143.9 %
	2050	sèche	61.6 %	66.1 %	108.4 %	116.3 %	38.3 %	42.8 %	67.4 %	75.4 %
		Normale	69.9 %	73.9 %	123.1 %	130.0 %	48.7 %	52.6 %	85.7 %	92.6 %
		Humide	120.1 %	125.3 %	211.5 %	220.4 %	81.6 %	86.7 %	143.7 %	152.7 %
Zone sud	2030	sèche	492.0 %	506.0 %	620.8 %	638.4 %	312.4 %	326.3 %	394.1 %	411.7 %
		Normale	442.9 %	464.2 %	558.8 %	585.7 %	284.1 %	305.4 %	358.4 %	385.3 %
		Humide	647.0 %	668.2 %	816.3 %	843.0 %	420.9 %	442.1 %	531.0 %	557.7 %
	2050	sèche	407.0 %	420.9 %	672.7 %	694.0& %	251.8 %	264.8 %	415.2 %	436.6 %
		Normale	306.2 %	320.0 %	504.9 %	527.6 %	192.6 %	206.4 %	317.6	340.3 %
		Humide	557.5 %	574.4 %	919.3 %	947.0 %	357.9 %	374.7 %	590.1 %	617.8 %

IV -3- les ressources hydriques en 2030 – 2050

En dépit de la courte durée dans le temps des données disponibles, une régression multiple est faite pour chercher les paramètres climatiques listés au paragraphe III-1-3 (paramètres explicatifs) qui expliquent au mieux la durée d'ennoiement des mares (paramètre à expliquer) d'une part et d'autre part les relations qui les lient.

Les modèles sélectionnés sont présentés dans le Tableau-11 et concernent l'ensemble des huit mares de l'étude. Pour chaque mare, le modèle retenu correspond à celui qui a montré à la fois le test F (significatif le plus faible) et le R^2 ajusté le plus important.

Tableau-11 : récapitulatif des meilleures modèles pour chaque mare.

Mares	Equation de régression	Valeur F	Pr > F	R^2 ajusté
Loumbolamar	-7.343+Tmin*0.597	0.26	0.64	-0.23
CirDoundou	23.62+Pluie*0.004-Tmoy*0.66	46.77	0.02	0.96
Namari	20.33+Pluie*0.003-Tmin*5.09+Tmoy*3.26	29.19	0.13	0.95
SinthiouFissa	39.59-Pluie*0.004-Tmax*0.86	4.56	0.18	0.64
Ngar	-37.12+Pluie*0.0007+Tmoy*1.43	4.57	0.18	0.64
Thioke	-28.59+Pluie*0.004+Tmax*0.86	4.56	0.18	0.64
Sode	67.43+Pluie*0.0005+Tmin*2.45-Tmoy*3.92	186	0.02	0.99
Inis	-8.343+Tmin*0.597	0.26	0.64	-0.23

Par la suite, les meilleures modèles ont été réparties en trois classes. Le premiers lot concerne les modèles satisfaisant, c'est-à-dire F de Fischer élevé avec un seuil inférieur d'erreur inférieur à 5% (mares de CirDoundou et Sode). Ensuite on a les modèles peut satisfaisant, qui on un F de Fischer assez élevé mais avec un seuil d'erreur compris entre 5 et 20% mais avec un R^2 ajusté proche de 1 (mares de Namari, SinthiouFissa, Ngar et Thioke. Et enfin les modèle non satisfaisant qui on un F de Fischer presque nul avec un seuil d'erreur de plus de 20% avec un R^2 ajusté négatif (mares de LoumbolAmar et Inis). Pour ce dernier lot, la projection n'a pas été faite. Pour la suite du travail, on a opté de faire la projection pour les mares ayant un modèle satisfaisant ou peut satisfaisant.

Le tableau-12 donne un récapitulatif des résultats de notre étude sur les ressources en eau. On constante qu'en général les ressources en eau des mares de CirDoundou et de Namari auront tendance à disparaître plus tôt comparé à aux cinq dernières années. Cette même tendance est observée pour les mares de Sodé et Sinthiou Fissa sauf pour les années 2050 en scénario humide et normal respectivement. Les mares de Thioké et Ngar par contre connaitront une amélioration de leur durée d'ennoiement allant même parfois jusqu'à devenir pérenne come c'est le cas pour 2030scénario humide et 2050 scénario sec. Mais il est bon de rappeler que les modèle de ces deux mares on un pourcentage de confiance de 18% ce qui est assez important.

Tableau-12 : Projection de la durée d'ennoiement des à l'horizon 2030 – 2050

Mares	Période ennoiment 5 dernières années	Modèles	Années	scénario	Durée d'ennoiement	mois
CirDoundou	Mars-Avril	Dem=23.62+Pluie *0.004 -Tmoy*0.66	2030	Sec	3.8	Janvier-Février
				Normal	4.5	Février-mars
				humide	3.2	Janvier-Février
			2050	Sec	3.3	Janvier-Février
				Normal	3.6	Janvier-Février
				humide	4.9	Février-mars
Sodé	Avril-Mai	Dem=67.43+Pluie*0.0005 +Tmin*2.45-Tmoy*3.92	2030	Sec	5.5	Mars-avril
				Normal	5.7	Mars-avril
				humide	2.9	Décembre-janvier
			2050	Sec	4.1	Février-mars
				Normal	5.7	Mars-avril
				humide	6.5	**Avril-mai**
Sinthiou Fissa	Mars-Avril	Dem=39.59-Pluie*0.004-Tmax*0.86	2030	Sec	4.5	Février-mars
				Normal	4.6	Février-mars
				humide	3.1	Janvier-Février
			2050	Sec	4.6	Février-mars
				Normal	5.6	**Mars-avril**
				humide	4.1	Février-mars
Ngar	Février-Avril	Dem=-37.12+Pluie*0.0007 +Tmoy*1.43	2030	Sec	7.1	**Mai-juin**
				Normal	7.0	**Mai-juin**
				humide	9.4	**Permanente**
			2050	Sec	8.6	**Permanente**
				Normal	7.9	**Mai-juin**
				humide	7.3	**Mai-juin**
Thioke	Mars-Avril	Dem=-28.59+Pluie*0.004 +Tmax*0.86	2030	Sec	6.5	**Avril-mai**
				Normal	6.4	**Avril-mai**
				humide	7.9	**Mai-juin**
			2050	Sec	6.4	**Avril-mai**
				Normal	5.4	**Mars-avril**
				humide	6.9	**Avril-mai**
Namari	Février-Avril	Dem=20.33+Pluie*0.003-Tmin*5.09+Tmoy*3.26	203	Sec	1	Novembre
				Normal	1.4	Novembre-Décembre
				humide	0	Avant novembre
			2050	Sec	0	Avant novembre
				Normal	0	Avant novembre
				humide	0	Avant novembre

Conclusion

Cette étude, qui se concentre sur la partie orientale du Sénégal, a pour objectif de mieux comprendre le comportement des ressources pastorale à l'horizon 2030 et 2050 en tenant compte des différents scénarios climatiques. Cette zone, ou l'élevage joue un rôle joue un rôle de premier plan dans l'économie des ménages reste sensible aux variabilités climatiques. En effet, les ressources pastorales (biomasse naturelle et eau), qui est la principale source de nourriture du bétail est fortement tributaire des conditions climatiques. Pour cette raison, et dans l'optique d'une amélioration de la capacité d'adaptation des populations de cette zone afin de favoriser une croissance économique que cette étude a été commanditée.

La méthodologie repose sur de modèles mathématiques qui ne sont rien d'autre qu'une combinaison des différentes relations qui lient les variables à expliquer (production de biomasse et durée d'ennoiement des mares) et les variables explicatifs qui sont les données climatiques. En effet, le modèle STEP (***S**ahelian **T**ranspiration **E**vaporation and **P**roduction model*) utilisé permet à partir des données climatiques de simulé la production fourragère. Les mares étant une source importante d'abreuvement du cheptel, on s'est intéressé à leur comportement pour les

années à venir en fonction des scénarios climatiques. Il a été ensuite de trouver les relations qui lient la durée d'ennoiement des mares aux paramètres climatiques.

Des données historiques sont utiliser pour calibrer les modèle et mieux contextualiser l'étude. En effet l'utilisation des ces donnés historique permet de d'estimer le biais des résultats des simulations par rapport aux mesures historiques des ressources pastorale. Ce biais sont ainsi corrigés sur les projections simulées. D'autre part, l'analyse des données historiques a permis d'évaluer les différentes situations possibles. Trois situation ont été observées (une situation de pluviométrie déficitaire (1992), une situation de pluviométrie normale (1987 et 1998), une situation de pluviométrie excédentaire (1988 et 1994)). L'analyse de production montre qu'en 1992 on a eu un déficit de disponible fourrager dans la zone nord de notre étude (département de Matam et Ranérou). Pour la zone sud (département de Bakel et Goudiry) la production a toujours été excédentaire. Cela du fait du faible peuplement des ruminants dans cette zone comparé au nord et de la non prise ne compte de la transhumance. En effet, partie du pays est une zone d'accueil de transhumant venu plus au nord et au centre du pays ou la production fourragère est parfois limitée. Sachant que la disponibilité en eau est un facteur limitant dans cette zone, la biomasse accessible a été calculée. Elle correspond à la biomasse se trouvant à moins de 20 km d'un point d'eau. Pour rappel, dans cette étude nous avons considéré que la biomasse disponible pour le bétail représente 1/3 de la biomasse totale conformément à ce que fait la Direction de l'élevage.

On constate donc que la zone nord va présenter un déficit fourrager à l'horizon 2030 et 2050 sauf pour le scénario optimiste (scénario humide). Si des dispositions ne sont pas prise pour augmenter les points d'eau et ainsi améliorer l'accès à l'eau, la situation à l'horizon 2030 et 2050 risque d'être pire que ce qu'on a connu en 1992. Surtout que la durée d'ennoiement des mares dans cette zone va diminuer. Le fourrage post-récolte reste insignifiant dans cette zone pour atténuer la tendance.

A l'inverse, dans la partie sud, la production fourragère sera toujours excédentaire. Mais plusieurs phénomènes peuvent affecter cette disponibilité. On peut citer l'extension des superficies agricole qui peut entrainer une diminution du disponible fourrager du fait que l'agriculture commence à gagner du terrain. La transhumance aussi peut être un facteur déterminant. En effet cette zone reste une zone d'accueil de transhumant venant non seulement de la partie nord de notre zone d'étude mais aussi du reste du pays ou le déficit fourrager se fait souvent sentir très tôt. La baise de la pluviométrie va s'accompagner avec la disparition de certains parasites et autres mouches qui font que certains animaux ne peuvent pas vivre dans la partie sud de la zone.

Le manque de données sur la transhumance nationale et transfrontalière alors que les spécialistes prédisent un accroissement constitue un des handicaps de cette étude. La non disponibilité d'une longue série de données sur les mares a aussi biaisé pour l'étude sur les ressources hydrique à l'horizon 2030 et 2050.

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ANNEX P. LOCAL ADAPTIVE PRACTICES IN THE LITERATURE

LIVELIHOOD DIVERSIFICATION

- Diversifying income sources; non-farm employment (Fleuret, 1986; Salem-Murdock, 1987; Corbett, 1988; Matlon, 1991; Cooper et al., 2008; Mertz et al., 2011; Dieye & Roy 2012; Ickowicz et al., 2012; Zorom et al., 2013)
- Incorporating livestock rearing (Ickowicz et al., 2012)
- Incorporating crop cultivation (Powell et al., 2004; Ickowicz et al., 2012)
- Migrating to rural or urban locations, seasonal, long-term, and permanent (Corbett, 1988; Zorom et al., 2013; Matlon & Kristjanson, 1988, cited by Cooper et al., 2008; Matlon, 1991)

SOCIAL NETWORKING

- Tapping into research institutions and agricultural/pastoral extension services to learn new technologies, access new seeds varieties, regulate conflict, etc. (Dieye & Roy, 2012; Zorom et al., 2013)
- Drawing on inter-household transfers and loans, borrowing (Corbett, 1988; Watts, 1983; Cooper et al., 2008)

HOUSEHOLD WEALTH MANAGEMENT

- Building an asset base for later sale (Watts, 1983; Corbett, 1988; Matlon, 1991; Fafchamps et al., 1998; Roncoli et al., 2001; Cooper et al., 2008; Sissoko et al., 2011)
- Purchasing food to meet basic needs (Clark, 1995)
- Taking credit from merchants and moneylenders (Corbett, 1988)

FARM MANAGEMENT PRACTICES

- Changing dates for field tasks such as land preparation, planting, and harvesting (Ickowicz et al., 2012)
- Cultivating dispersed plots in different agro-ecological zones or at different elevations (Fleuret, 1986; Clark, 1995)
- Moving cultivation to new lands in a different agro-ecological zone or at a different elevation (Matlon & Kristjanson, 1988, cited by Cooper et al., 2008)
- Planting over a greater surface (Ickowicz et al., 2012)
- Staggering and sequencing plantings dates to optimize production and labor efficiency (Ickowicz et al., 2012)
- Investing in water management and rainwater harvesting (Cooper et al., 2008; Tabor, 1995)
- Irrigation (Dieye & Roy, 2012; Zorom et al., 2013)
- Changing seed to drought-resistant and locally adapted varieties (Matlon & Kristjanson, 1988; Roncoli et al., 2001; Cooper et al., 2008; Ickowicz et al., 2012; Roncoli et al., 2001)
- Replanting with earlier maturing varieties (Matlon & Kristjanson, 1988, cited by Cooper et al., 2008)

- Planting late for forage (Matlon & Kristjanson, 1988, cited by Cooper et al., 2008)

NATURAL RESOURCE MANAGEMENT

- Maintenance and recovery of forest cover and soil conservation (Clark, 1995)
- Integrating agroforestry systems and active management of wild plants/trees (Clark, 1995; Adams et al., 1998)

HERD MANAGEMENT

- Moving herds to resource-rich regions (Swift, 1977; Juul, 1996, 2005; Ickowicz et al., 2012).
- Moving herds greater distances (Ickowicz et al., 2012)
- Changing herd species composition, such as increased proportion of small ruminants. (McIntire, 1991, cited by Cooper et al., 2008; Adriansen, 2006; Ickowicz et al., 2012)
- Increasing commercialization, such as shifting to fattening, shifting from milk to beef production (McIntire, 1991, cited by Cooper et al., 2008; Adriansen, 2006; Ickowicz et al., 2012; Adriansen, 2006)
- Splitting herds into multiple discrete herds (McIntire, 1991, cited by Cooper et al., 2008)
- Intensification and sedentarization of livestock production (Powell et al., 2004; Adriansen, 2006)
- Managing sheep birthing so that lambs are born shortly after rains (Swift, in Copans, 1975)

ANNOTATED BIBLIOGRAPHY ON ADAPTATION TO CLIMATE CHANGE IN SENEGAL

Adams, A. M., Cekan, J. et al. (1998). Towards a conceptual framework of household coping: Reflections from rural West Africa. *Africa: Journal of the International African Institute 68(2),* 263-283.

The study and application of household coping have largely been confined to the problems of famine and food insecurity. Based on field insights from West Africa, this paper argues that understanding how households cope and allocate resources in times of crisis is of immense value to a broad array of development interventions. It also introduces a conceptual framework that evaluates household coping in exogenous and endogenous contexts. The application of this framework may provide a more informed approach to development intervention design, implementation, and targeting that is sensitive to the different needs and experiences of rural households and communities.

Adriansen, H., & Nielsen, T. (2002). Going where the grass is greener: On the study of pastoral mobility in Ferlo, Senegal. *Human Ecology, 30(2)*, 215-226.

Based on a case study from Ferlo in Senegal, this paper discusses how pastoral mobility can be studied and understood with special emphasis on the use of GPS data. It has a dual objective: first, to investigate the methodological potential of using GPS data; second, to discuss the analytical use of GPS data for understanding mobility. The methodological potential for using GPS data is related to quantifying mobility and characterizing mobility patterns in space and time. Analytically, GPS data can be used in combination with qualitative information to make method triangulation. The GPS data can be used both prior to qualitative interviews, to help frame informed questions about mobility, and after qualitative investigations, to illustrate points made

or to reveal inconsistencies. The study shows that cattle walk about 5000 km per year (excluding night grazing) and that different mobility patterns occur depending on the season. Issues such as "the cattle complex" and the notion of the independent, nomadic pastoralist are discussed in relation to pastoral mobility. Although cattle are of major importance to the Fulani, it is not important for Fulani to walk with their animals, which are left to roam freely or supervised by paid herders. It is necessary to take into account all of these issues if we want to go beyond the simple understanding of mobility as a means to find pasture and water.

Adriansen, H. K. (2006). Continuity and change in pastoral livelihoods of Senegalese Fulani. *Agriculture and Human Values, 23(2),* 215-229.

Based on fieldwork in northern Senegal, this paper shows how some pastoralists in Ferlo have managed to use market opportunities as a means to maintain their "pastoral way of life." Increased market involvement has enlarged the field of opportunities for pastoral activities as well as the vulnerability of these activities. This has given rise to a dialectic process of diversification and specialization. The paper is concerned with the portfolio of livelihood activities pastoralists use in order to respond to adverse socio-economic and environmental conditions. Depending on the possibilities and values of a household, a certain combination of activities is chosen, and this may change from one year to another. Hence, the activities are used in a dynamic way within households. On the basis of pastoral livelihood activities, four ideal types of pastoral livelihood strategies can be constructed: "agro-pastoralism," "Tabaski pastoralism," "commercial pastoralism," and "non-herding pastoralism." These four types illustrate how pastoralists re-invent their livelihoods in order to continue a pastoral way of life.

Adriansen, H. K. (2008). Understanding pastoral mobility: the case of Senegalese Fulani. *Geographical Journal, 174(3),* 207-222.

Based on a case study from Sahelian Senegal, this paper analyses how various actors perceive the importance of pastoral mobility and presents issues of importance for understanding the use of mobility among Fulani of Ferlo. One knowledge system is a scientific one, known as the "new rangeland paradigm." According to this paradigm, pastoral mobility is a means to balance variability in dryland resources; hence, "'nature" is the point of departure. Another knowledge system is local pastoral knowledge. For the pastoralists, the well-being of their animals is the point of departure, and mobility is used to ensure that the livestock are in good condition. The paper shows that it is important to distinguish between mobility of pastoralists and of their herd; even though the pastoralists of northern Senegal have become semi-sedentary, their herds are still quite mobile. The pastoralists are willing to move around within a small territory, which they consider their place, but are unwilling to employ large-scale mobility themselves. Mobility is not of importance for their ethnic identity and some use paid herders to care for their livestock. By looking at both knowledge systems, we achieve a better understanding of pastoral mobility and how this may change in the future.

Ancey, V. & Ickowicz, A. et al. (2009). *Stratégies pastorales de sécurisation chez les Peuls du Ferlo (Sénégal). Journal des Africanistes (online) 78(1/2).*

To Fulani (Peul) herders of Senegalese Ferlo, socio-economic and symbolic links between settlements and cattle encounter significative change, with an increasing economic part played by small ruminants, which are not taking over but rather complementing the cultural references and strategies represented by cattle. Various rules of management are linked to specific strategies.

Chez les pasteurs peuls du Ferlo, les liens socio-économiques et symboliques entre le campement et son troupeau bovin connaissent de grands changements, marqués notamment par le rôle économique

croissant des petits ruminants. Différents modes de gestion se mettent en place qui renvoient à des stratégies de protection contre les risques.

Ancey, V. & Monas, G. (2005). *Le pastoralisme au Sénégal, entre politique "moderne" et gestion des risques par les pasteurs.* (Pastoralism in Senegal: Between modern policy and risk management by livestock raisers). *Revue Tiers Monde 4,* 761-783.

The question of livestock raising in Senegal well illustrates how difficult it is, at times, for policies to take some realities into account. While such policies promptly mobilize recent concepts (such as food sovereignty) or propose modernist network approaches, discourses still often convey ancient clichés on the atavism and irrationality of pastoralists, along with ignorance of local, economic, agro-ecological and societal realities. It is such biased representations that this article puts to question, by examining the sectoral policy implemented in Senegal in order to secure local production systems.

La question de l'élevage pastoral au Sénégal illustre bien les difficultés qu'ont parfois les politiques à prendre en compte certaines réalités. Si ces politiques sont promptes à mobiliser certains concepts récents (souveraineté alimentaire) ou à proposer des approches modernisantes pour les filières, les discours véhiculent encore souvent des clichés anciens sur l'atavisme ou l'irrationalité des éleveurs et une méconnaissance des réalités locales, économiques, agro-écologiques et sociétales. Ce sont ces représentations biaisées que cet article entend questionner en examinant la politique sectorielle mise en œuvre au Sénégal dans une perspective de sécurisation durable des systèmes locaux de production.

Bass, B., Venema, H. et al. (1996) Adaptation of food production to drought in the Senegal River Basin. *Climate Change and World Food Security, Proceedings of the NATO Advanced Research Workshop on Climate Change and World Food Security, held in Oxford, U.K., July 11-15, 1993. T. E. Downing. Berlin Heidelberg New York, Springer-Verlag. 37*: 485-503.

This book addresses the threat of climate change to world food security. It provides an authoritative review of climate change, surprising, contrasting trends in world food security, case studies of food and the environment, and chapters on adaptive responses. It reviews trends in agriculture and food security, including projections of the incidence and distribution of hunger over the next few decades; the risk and global impacts of climate change on agricultural systems, relying on alternative models of world agricultural potential that have simulated the impacts of climate change; vulnerability and multiple threats to sustainable agriculture; studies of local impacts and responses; and strategies to limit climate change and improve food security.

Bénéfice, E., Chevassus-Agnes, S. et al. (1984). Nutritional situation and seasonal variations for pastoralist populations of the Sahel (Senegalese Ferlo). *Ecology of Food and Nutrition 14(3),* 229-247.

The nutritional status and food consumption of a population of herders in the Ferlo (Senegal) was studied during a complete seasonal cycle. The Ferlo region is in the Sahelian climatic belt where a long dry season (nine to ten months) alternates with a brief humid season (two to three months). In the existing traditional livestock production system, these climatic variations have an impact; first, on the living conditions of these herders, but also on their nutritional status. Food intakes are insufficient during the rains, and one finds a deep nutritional depression during this period; during the dry season, to the contrary, food intake is very good and the nutritional status definitely improves. In an average situation, there is a balance between the losses that occur during the wet season and the gains made at the beginning of the dry season. This balance is nevertheless very precarious. To insure food and nutritional security for the herders, activities must concentrate on seeking solutions that will not threaten their social organization or their lifestyle.

Bénéfice, E. & Simondon, K. (1993). Agricultural development and nutrition among rural populations: A case study of the middle valley in Senegal. *Ecology of Food and Nutrition 31(1-2),* 45-66.

Food production in Sahelian countries is highly dependent on erratic rainfall. To eliminate this climatic risk, modern irrigated agriculture was introduced to the area; its use has spread in the Senegal Valley during the last 30 years. In such a context of changes in farming systems and food consumption patterns, a nutritional and dietary study was conducted three different times at six month intervals among 37 families of a village community which farmed a recently established irrigated area. Women played an important part in agricultural tasks. Average food consumption met the recommended intake for energy but deficiencies persisted for certain nutrients. The prevalence of malnutrition was high, with 16 percent stunting and 13 percent wasting among children between the ages of 0 and 10 years; a third of the older children and 20 percent of the adults presented an emaciated appearance. Rice production has increased food security but, in comparison with the situation in the valley 35 years ago, nutritional gains were slight and there were no differences in the malnutrition rate of preschool children from that observed nine years earlier in a non-irrigated neighboring area. The findings suggest increase in food production following the introduction of irrigation without improvement of hygienic conditions is not sufficient to ameliorate nutritional deficiencies in communities. The consequences of added work load in habitual physical activity need to be considered as well, particularly when, as is the case here, food production is, in part, the result of efforts of women.

Binns, J. A. (1987). Inequality and development in rural West Africa. *GeoJournal 14(1),* 77-86.

Inequality seems to be a feature of all societies, but some are probably more equal than others. It is in Third World countries, however, where the inequalities between particular areas, groups, and individuals are most marked. This paper traces the growing interest in both the study of inequality and the rural household as a focus of analysis. Some of the problems of measuring inequality are then considered, and various indicators of inequality are examined with reference to empirical evidence from rural West Africa. The paper concludes that recent development strategies have often directly or indirectly led to greater rural inequality. It also suggests how future projects might achieve greater impact in reducing the gap between rich and poor.

Black, R. & Sessay, M. (1998). Forced migration, natural resource use, and environmental change: The case of the Senegal River Valley. *International Journal of Population Geography 4(1),* 1099-1220.

This paper addresses concerns about the potentially negative environmental consequences of mass population displacement by examining changes in natural resource use in an area of northern Senegal affected by an influx of Mauritanian refugees in 1989. Drawing on a survey of refugee and local households, the paper examines the livelihood strategies and patterns of natural resource use of the two populations, and considers the notion that refugees are forced, through poverty or for other reasons, to use natural resources in a more destructive manner. The paper also considers the regulation of natural resource use, and the socio-economic and political context within which this resource use takes place. The paper concludes that there is little justification for viewing refugees in the Senegal River Valley as "exceptional resource degraders," but rather that the livelihood strategies developed by refugees are similar, in many respects, to those of local populations.

Blench, R. & Marriage, Z. (1999). Drought and livestock in semi-arid Africa and southwest Asia. *Working Paper 117*. London, Overseas Development Institute.

Bradley, D. & Grainger, A. (2004). Social resilience as a controlling influence on desertification in Senegal. *Land Degradation & Development 15(5),* 451-470.

While ecological resilience may explain why apparent symptoms of desertification are often temporary, social resilience can prevent degradation resulting from overexploitation of land in response to drought and other constraints. This paper describes a Social Resilience Model in which actors switch from performance strategies to survival strategies when the perceived severity of constraints exceeds a critical performance–survival threshold (PST). This is determined in comparison with a reference mode that depends on a learning facility developed by repeated exposure to cycles of constraint, search, and feedback. Actors select particular strategies by comparing welfare gains with their aspiration levels—a concept that allows more flexible decision making than profit maximizing or sacrificing alone. The model is tested in the silvopastoral zone of Senegal, where desertification is not as widespread as commonly assumed, despite severe constraints. The two major ethnic groups, the Wolof (mainly croppers) and the Peul (mainly pastoralists) anticipate and respond to environmental and socio-economic constraints differently, and have different performance and survival strategies. The Peul have the higher social resilience, with more flexible decision-making objectives, greater mobility, a more extensive action space, a learning facility supporting efficient search and feedback processes, a reference mode attuned to high anticipation and recognition of stress, and a high PST. They also exhibit more continuous performance–survival switching than the Wolof, who make a radical change from cropping to labour migration and reliance on external support.

Chastanet, M. (1983). *Les crises de subsistances dans les villages soninke du cercle de Bakel, de 1858 à 1945: problèmes méthodologiques et perspectives de recherches* (Subsistence crises in the Soninke villages of Bakel District, 1858-1945: problems of method and research prospects). *Cahiers d'Études Africaines 23(89-90),* 5-36.

This paper offers a method for the analysis of subsistence crises in Africa during the colonial period. Lacking the long homogeneous statistical series generally used for the location and description of the European famines of the Ancien Regime, we have established a chronology based upon district reports and retrospective enquiries in the Soninke villages. In view of the strong correlation between the length of a crisis and its seriousness, we have set up a typology of crises and distinguished, according to their duration, between "scarcity," "famine," and "serious famine." This chronology reveals sequential crises inscribing the production system and social life within a pluri-annual cycle with food shortages appearing as a structural trait. This chronological series is but a step in the analysis of subsistence crises; it must eventually be correlated with ecological, socioeconomic and political data in order to understand the conditions of subsistence crises outbreaks, their impact, and related social dynamics during the colonial period.

Chastanet, M. (1992). Survival strategies of a Sahelian society: The case of the Soninke in Senegal from the middle of the nineteenth century to the present. *Food and Foodways 5(2),* 127-149.

Clark, A. F. (1995). Environmental decline and ecological response in the upper Senegal valley, West Africa, from the late nineteenth century to World War I. *The Journal of African History 36(2)*, 197-218.

The upper Senegal valley of West Africa, like other areas of Africa, experienced a period of acute environmental decline and intense ecological response by residents from the late nineteenth century until World War I. French colonial strategies caused considerable disruption and dislocation, benefitting, in many ways, the colonial agenda, which sought to regulate labor flows. African responses to the widening crisis, including movement within the region, migration to the peanut basin and the coast, and enlistment in the war effort, often served colonial interests while sometimes directly exacerbating the environmental degradation, necessitating

constant ecological adaptation. This study of an early period of intense and well-documented physical decline, and the various strategies developed by West Africans to survive and overcome obstacles, can shed light on current environmental policy debates and issues.

Cohn, T. (1975). The Sahelian Drought: Problems of Land Use. *International Journal, 30(3),* 428-444.

Cooper, P. J. M., Dimes, J. et al. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? *Agriculture, Ecosystems & Environment, 126(1–2),* 24-35.

Rain-fed agriculture will remain the dominant source of staple food production and the livelihood foundation of the majority of the rural poor in sub-Saharan Africa (SSA). Greatly enhanced investment in agriculture by a broad range of stakeholders will be required if this sector is to meet the food security requirements of tomorrow's Africa. However, production uncertainty associated with between- and within-season rainfall variability remains a fundamental constraint to many investors, who often overestimate the negative impacts of climate induced uncertainty. Climate change is likely to make matters worse, with increases in rainfall variability being predicted. The ability of agricultural communities and agricultural stakeholders in SSA to cope better with the constraints and opportunities of current climate variability must first be enhanced for them to be able to adapt to climate change and the predicted future increase in climate variability. Tools and approaches are now available that allow for a better understanding, characterization, and mapping of the agricultural implications of climate variability and the development of climate risk management strategies specifically tailored to stakeholders needs. Application of these tools allows the development and dissemination of targeted investment innovations that have a high probability of biophysical and economic success in the context of climate variability.

Copans, J. (1975). *Sécheresses et famines au Sahel. Ecologie, Dénutrition, Assistance. Dossiers africains, Editions François Maspero,* 144p

Copans, J. (1979). Droughts, famines and the evolution of Senegal (1966-1978). *Mass Emergencies, 4,* 87-93.

Corbett, J. (1988). Famine and household coping strategies. *World Development, 16(9),* 1099-1112.

Households faced with risks to their entitlement to food will plan strategically to minimize its impact. This task is particularly demanding during famines. This paper reviews the evidence on household strategies for coping with famine in Africa and identifies some distinctive patterns in these strategies that can be used to examine household objectives at times of crisis, the management of resources to meet these objectives, and limits to the effectiveness of coping strategies. In particular, it examines the role of asset management and trade-offs between maintaining current food consumption levels and protecting the future income-generating capacity of the household.

Corniaux, C., Alary, V. et al. (2012). *Producteur laitier en Afrique de l'Ouest: une modernité rêvée par les techniciens à l'épreuve du terrain.* (Modern dairy farmers in West Africa: Technicist dream or reality?). *Autrepart, 3,* 17-36.

Does West Africa have "modern" dairy farmers who are conforming to developed countries agricultural models and able, according to the modern rhetorical discourse, to face the competition of imported milk powder? Understanding who the West African dairy farmers are is required to answer this question. This analysis, based on three typologies established for the periphery of cities in Senegal, Mauritania, and Mali, shows a wide variety of situations. However, safe-production strategy dominates in an environment of relatively poor family farms favoring

cereals cultivation or livestock. Milk is not an economic priority in the current system of production, and Western-type dairy producers do not yet exist in West Africa.

À l'instar des modèles de développement agricole en Occident, existe-t-il en Afrique de l'Ouest des producteurs laitiers « modernes » capables, selon la réthorique modernisante, d'affronter la concurrence du lait en poudre importé ? Pour répondre à cette question, il est nécessaire de savoir qui sont les producteurs laitiers ouest-africains. Notre analyse, basée sur trois typologies réalisées en périphérie des villes au Sénégal, en Mauritanie et au Mali, montre une grande diversité de situations. Néanmoins, la stratégie dominante est une stratégie sécuritaire, dans le cadre d'exploitations familiales relativement pauvres qui privilégient la production de céréales ou d'animaux sur pieds. Le lait n'est pas une priorité économique dans le système actuel de production. La figure du producteur laitier à l'occidentale n'existe pas encore en Afrique de l'Ouest.

Cotula, L. (2008). The property rights challenges of improving access to water for agriculture: Lessons from the Sahel. *Journal of Human Development, 9(1),* 5-22.

In the Sahel, efforts have been made to improve access to water for agriculture through the creation of irrigation schemes and pastoral water points. In the past, decisions on the construction and operation of these water facilities were typically based on hydrological and technical factors alone, while issues concerning the rights of local people before and after water development projects have often been neglected. However, if these issues are not properly addressed, such projects can foster disputes, undermine the security of resource rights, and contribute to resource degradation. Drawing on the analysis of relevant legislation, on a literature review, and on original fieldwork, this paper tackles the property rights issues raised by the creation and operation of irrigation schemes and pastoral water points, focusing on four Sahelian countries: Senegal, Mali, Burkina Faso, and Niger.

Derrick, J. (1977). The Great West African Drought, 1972-1974. *African Affairs 76(305)*, 537-586.

In 1972 and 1973 the annual rains in much of the savanna belt of West Africa were seriously below average, and agriculture and stock-breeding were badly affected, in some places disastrously. In a situation in which most of the people depended for their livelihood on the farming and herding activities hit by the low rainfall, and where there were few other resources on which to fall back, the drought was an economic disaster for millions. It was, in fact, the worst natural disaster in the area since a similar drought in 1911-14. It led to massive local and international relief efforts, which brought in hundreds of thousands of tons of aid but which was not enough to prevent great suffering, well publicized at the time in the world at large. In 1974 good rains fell again over much of the affected area, and while it is too early to assume that the climate and the activities dependent on it are wholly back to normal, the immediate drought crisis has passed. It is now possible to summarize, briefly, the nature and effects of a disaster, which most emergency reports at the time could not adequately study.

Derrick, J. (1984). West Africa's worst year of famine. *African Affairs, 83(332),* 281-299.

Diagne, M., Demont, M. et al. (2013). Self-sufficiency policy and irrigated rice productivity in the Senegal River Valley. *Food Security, 5(1),* 55-68.

Senegal's high dependence on rice imports exposes the country to international market shocks with concomitant serious risks for food security. Triggered by high international prices, several initiatives to upgrade the rice value chain have emerged in the private sector since 2011. However, the major constraint private investors are currently facing is the insufficient supply of Senegal River Valley (SRV) paddy rice, implying that investment in productivity is becoming vital for the continuation of their operations, which are currently running below their optimum. The

Senegalese government is investing heavily in the national rice sector, with the ambitious objective of achieving self-sufficiency in the year 2015. However, the program focuses primarily on extension of the area grown rather than increased productivity. The authors provide econometric support for policy making by assessing the determinants of productivity and technical efficiency in irrigated rice production systems through a five-year panel dataset of small-scale irrigated rice farms in the SRV. They found that due to the exacerbation of biological and institutional constraints in the SRV, rice growers had difficulty maintaining the productivity of their land. These constraints prevented them from further intensification, jeopardizing the national objective of self-sufficiency. Farmers exhibited modest technical efficiency levels, suggesting that, in addition to the proposed intensification strategies, substantial efforts in extension services will be required in order to achieve the goal of self-sufficiency. Improved weed and bird control as well as technological, organizational, and institutional improvements were identified as key factors for boosting productivity and technical efficiency and, hence, these are target areas needing attention by Senegalese farmers and policy makers in their quest for increased food security.

Dieye, A. M. & Roy, D. P. (2012). A study of rural Senegalese attitudes and perceptions of their behavior to changes in the climate. *Environmental Management, 50(5)*, 929-941.

Semi-structured focus group discussions were employed to capture rural Senegalese attitudes and perceptions of their behavior to changes in the climate and their land use and livelihood strategies. Seven focus groups stratified by gender, ethnicity (Wolof and Peulh) and dominant production system (cultivators and pastoralists) in five villages in semi-arid northern Senegal revealed seven main themes. Rural livelihoods remain predominantly based on rainfall-dependent practices, and although cultivators and pastoralists had a clear appreciation of changes in natural resources compared to the past, which they perceived in a more favorable light, few adaptive coping strategies beyond established ones were advocated. The seven themes and their implications for rural livelihoods under future long-term climate predictions are discussed in detail, as well as the implications of this study for the development of scenarios of future land cover land use.

Dumas, D., Mietton, M. et al. (2010). Large dams and uncertainties: The case of the Senegal River (West Africa). *Society & Natural Resources, 23(11),* 1108-1122.

This article examines the environmental and socioeconomic consequences of hydraulic infrastructural changes along the Senegal River valley and estuary. During the 1980s, two dams were built along the valley floor to facilitate hydroelectrical production and regular water supply for crop irrigation. In 2003, a breach was dug across Barbary Spit to alleviate flooding in the nearby Saint-Louis city. Although these structures helped regulate the river flow, they also resulted in a series of unforeseen impacts. This study examines these impacts, and provides an analysis of post-construction on-site measurements (topometry, water salinity, piezometry), hydrological data, field observations, and surveys with dam managers, state regional directions, and local stakeholders. It stresses the urgency of elaborating models of hydraulic management to limit the negative consequences of the hydraulic constructions. These models should consider the variety of water uses in the middle valley and delta, and also water safety and quality (salinity) downriver from Diama Dam.

Ellis, J. & Galvin, K. A. (1994). Climate patterns and land-use practices in the dry zones of Africa. *BioScience, 44(5),* 340-349.

Fafchamps, M., Udry, C. et al. (1998). Drought and saving in West Africa: are livestock a buffer stock? *Journal of Development Economics, 55(2),* 273-305.

Households in the West African semi-arid tropics (WASAT) face substantial risk—an inevitable consequence of engaging in rainfed agriculture in a drought-prone environment. It has long been hypothesized that these households keep livestock as a buffer stock to insulate their consumption from income fluctuations. This paper tests this hypothesis. Results indicate that livestock transactions play less of a consumption smoothing role than often assumed. Livestock sales compensate for, at most, 30 percent, and probably closer to 15 percent, of income shortfalls due to village-level shocks alone. The authors discuss possible explanations for these results and suggest directions for future work.

Findley, S. E. (1994). Does drought increase migration? A study of migration from rural Mali during the 1983-1985 drought. *International Migration Review, 28(3)*, 539-553.

Using data from a longitudinal panel study conducted in 1982 and 1989 in the first region of Mali, this article demonstrates that the level of migration did not rise during the drought of 1983-1985. However, there was a dramatic increase in the migration of women and children during the severe 1983-1985 drought. Along with this increase in migration by women and children, there was a shift to short-cycle circulation, with 64 percent of the migrants adopting circular patterns. The study describes the characteristics of these migrants and recommends changes to development and migration policies that will facilitate such migrations in subsequent droughts.

Fleuret, A. (1986). Indigenous responses to drought in sub-Saharan Africa. *Disasters, 10(3),* 224-229.

Drought is a frequent occurrence in contemporary sub-Saharan Africa, and the existence of periodic drought can be documented over hundreds of years. As a consequence of the routine rainfall shortages that affect them, agricultural and pastoral societies have developed a number of social institutions and mechanisms for bridging temporary food production shortfalls caused by drought. Drawing on the literature and field data from southeastern Kenya, this paper discusses a number of regular indigenous responses to short-term drought in sub-Saharan Africa. Changes in these patterns in the present day are also discussed. The author concludes that market-based responses are now the most important strategies, but that traditional institutions remain significant and contribute to the viability of drought-affected societies.

Galvin, K. A. (1992). Nutritional ecology of pastoralists in dry tropical Africa. *American Journal of Human Biology, 4(2),* 209-221.

African pastoralists inhabit a variety of environments within tropical arid to semiarid regions. Ecological and cultural factors as well as economic opportunities and constraints influence the amounts and types of foods available. The preferred staple of all pastoral populations is milk from livestock. Pastoral diets are low in energy, but apparently adequate in protein. Growth in children is slow until late adolescence when height approaches the 50th percentile of reference data. Adult pastoralists are correspondingly tall and lean. Maintenance of high human numbers within the economy is a common strategy among a variety of pastoralists. The result is that pastoralists appear to be near the lower threshold of reasonable nutritional status at most times. This occurs despite marked variation in such elements as livestock and human numbers, diet composition, and activity patterns.

Galvin, K. A. (2009). Transitions: pastoralists living with change. *Annual Review of Anthropology 38(1),* 185-198.

This review covers two major causes of change in pastoral systems. First is fragmentation, the dissection of a natural system into spatially isolated parts, which is caused by a number of socioeconomic factors such as changes in land tenure, agriculture, sedentarization, and institutions. Second is climate change and climate variability, which are expected to alter dry and

semiarid grasslands now and into the future. Details of these changes are described using examples from Africa and Mongolia. An adaptation framework is used to place global change in context. Although pastoral systems are clearly under numerous constraints and risks have intensified, pastoralists are adapting and trying to remain flexible. It is too early to determine if their responses are adequate, given the magnitude and number of changes faced by pastoralists today.

Gning, M. C. (2004). Trade, political influence, and liberalization: Situating the poor in the political economy of livestock in Senegal. *Pro-Poor Livestock Policy Initiative (PPLPI) Working Paper No. 8.* Rome, Italy. Food and Agriculture Organization (FAO).

This paper presents a case study of how livestock policies are made and implemented in a national context, and how they can be improved to better serve the interests of the poor. In Senegal, approximately one-third of all households depend on livestock for some portion of their livelihood, yet this sector has not received significant state or private investment, nor has it received a significant amount of bi-lateral and international assistance. The study used the key informant method supplemented with official documents, newspaper sources, and recently published research on the livestock sector. Interviews helped reveal policymakers' concerns, whereas field trips allowed the researcher to talk to farmers and learn their perspectives from the bottom. Newspapers contained many lively stories about how well-intentioned policies went awry at the implementation stage, while published research analyzed various political, institutional, and technical aspects of policymaking in the sector. The author concludes that poor producers in the sector remain relatively unorganized and disadvantaged in the policy-formation process. Macro-economic forces and the distribution of political influence focus state attention on the concerns of large-scale producers and importers of dairy and poultry products rather than on the concerns of poor producers. The unexpected alliance between human rights organizations, some of the most active public pressure groups in Senegal today, and livestock producers during *l'affaire du Doli,* however, demonstrates the potential for new-issue linkages to strengthen the political position of livestock producers. Strategic entry points are recommended that can both improve the performance of the sector and the participation of the poor in productive activities. With sufficient resources to back up programs and efforts to identify political allies for the cause, it may be possible to make livestock policies better serve the interests of the poor.

Hein, L., Metzger, M. et al. (2009). The local impacts of climate change in the Ferlo, Western Sahel. *Climatic Change, 93(3-4)*, 465-483.

Recent increases in the accuracy of climate models have enhanced the possibilities for analyzing the impacts of climate change on society. This paper explores how the local, economic impacts of climate change can be modeled for a specific eco-region: the Western Sahel. The people in the Sahel are highly dependent on their natural resource base, and these resources are highly vulnerable to climate change, and in particular, to changes in rainfall. Climate models project substantial changes in rainfall in the Sahel in the coming 50 years, with most models predicting a reduction in rainfall. To connect climate change to changes in ecosystem productivity and local income, we construct an ecological–economic model that incorporates rangeland dynamics, grazing, and livestock prices. The model shows that decreased rainfall in the Sahel will considerably reduce local incomes, particularly if combined with increases in rainfall variability. Adaptation to these climate change projections is possible if reductions in rainfall are followed by destocking to reach efficient grazing levels. However, while such a strategy is optimal from the perspective of society, the stocking rate is determined by individual pastoralists that face few incentives to destock.

Herrmann, S. M. & Tappan, G. G. (2013). Vegetation impoverishment despite greening: A case study from central Senegal. *Journal of Arid Environments, 90,* 55-66.

Recent remote sensing studies have documented a greening trend in the semi-arid Sahel and Sudan zones of West Africa since the early 1980s, which challenges the mainstream paradigm of irreversible land degradation in this region. What the greening trend means on the ground, however, has not yet been explored. This research focuses on a region in central Senegal to examine changes in woody vegetation abundance and composition in selected sites by means of a botanical inventory of woody vegetation species, repeat photography, and perceptions of local land users. Despite the greening, an impoverishment of the woody vegetation cover was observed in the studied sites, indicated by an overall reduction in woody species richness, a loss of large trees, an increasing dominance of shrubs, and a shift towards more arid-tolerant Sahelian species since 1983. Thus, interpretation of the satellite-derived greening trend as an improvement or recovery is not always justified. The case of central Senegal represents only one of several possible pathways of greening throughout the region, all of which result in similar satellite-derived greening signals.

Horowitz, M. M. (1991). Victims upstream and down. *Journal of Refugee Studies, 4(2),* 164-181.

Persons living in the planned reservoir areas of large dams constitute classic instances of involuntary relocatees, and the largest funding institution for these dams in the Third World, the World Bank, has elaborated guidelines for their resettlement. Guidelines are necessary but insufficient steps in confronting victimization from development actions, first, because they are often ignored, and second, because there are no guidelines to protect the often larger number of persons downstream from dams who experience environmental, economic, and political dislocations. The Senegal River Valley is a current case in which dam construction and water management policy will inflict hardships both upstream and downstream, but only upstream has there been any attempt to compensate people for their losses. A different management policy would contribute to mitigating many of the downstream hardships without causing losses in either hydropower or irrigation. Whether so enlightened a policy will be adopted remains problematic.

Horowitz, M. M. & Salem-Murdock, M. (1993). Development-induced food insecurity in the middle Senegal Valley. *GeoJournal, 30(2),* 179-184.

Ickowicz, A., Ancey, M. et al. (2012). Crop-livestock production systems in the Sahel—Increasing resilience for adaptation to climate change and preserving food security. Building resilience for adaptation to climate change in the agriculture sector. *Proceedings of a Joint FAO/OECD Workshop,* Rome, Italy, 23-24 April 2012. Meybeck, A., Lankoski, J., Redfern, S., Azzu, N., and Gitz, V. Rome, Italy. FAO and OECD: 261-294.

Nowadays, the rural people in the Sahelian part of Africa are faced with new challenges such as high demographic growth (4 percent on average), climate change, environmental concerns, and global market changes. These challenges have had major local impacts on their production system organization, dynamics, and viability. This paper discusses how livestock production systems in the Sahel, whether associated with cropping activities or not, have been shaped by this highly variable environment, as well as what can be said about rural people's ability to cope with the new challenges and maintain their production systems and way of life (i.e., resilience). It analyses how public policies could enhance their adaptive capacities to further changes and ensure population food security. Whereas the main ecological and socio-economic characteristics of production systems in the Sahelian part of Africa are broadly similar from Senegal in the West to Ethiopia in the East, this paper focuses on the countries of the Western part of the Sahel (Senegal, Mali, Burkina Faso, and the Niger).

Juul, K. (1993). Pastoral tenure problems and local resource management: The case of Northern Senegal. *Nomadic Peoples, 32,* 81–91.

Juul, K. (1996). Post-drought migration and technological innovations among Fulani herders in Senegal: The triumph of the tube! *Drylands Issue Paper, 64.* London, International Institute for Environment and Development (IIED).

Juul, K. (2005). Transhumance, tubes, and telephones: Drought-related migration as a process of innovation. Beyond Territory and Scarcity: Exploring Conflicts over Natural Resource Management. Gausset, Q., Whyte, M. A., and Birch-Thomsen, T. Stockholm, *Elanders Gotab*, 112–134.

Scarcity is often connected with territoriality and boundedness. However, the migration of environmental refugees is not regarded as a solution to the problem of the imbalance between population pressure and scarce resources. Rather, population movements across territories have been perceived as a mechanism for spreading over-exploitation and degradation. As part of a general perspective of crisis and disaster, drought-related migration has been perceived first and foremost as the ultimate exit option for drought-ridden herders who are trying to avoid total destitution, while resource conflicts are seen as the immediate result of increasing pressure on a limited resource base. Findings from northern Senegal collected over a period between 1988 and 2002 do not confirm this gloomy picture of a production system in crisis. In this case, drought-related migration acted as a catalyst for change, as the drought refugees on their move southwards were forced to develop new and more efficient herd-management strategies, which in the end also benefited the indigenous population in the area of settlement. Due to the skilful ways in which these entrepreneurial migrants adapted to the new situation, in many ways, the post-drought period turned into period of increased opportunities. Although many conflicts were played out over access to water and pastures, these could be attributed more to social and political control issues than to scarce resources.

Kane, C., & Humbert, J. et al. (2013). Responding to climate variability: The opening of an artificial mouth on the Senegal River. *Regional Environmental Change 13(1),* 125-136.

The city of Saint-Louis is marked by recurrent floods, despite a decrease in rainfall. The town that grew downstream the vast plain where Senegalese-Mauritanian basin topography flattens considerably has experienced periodic flooding since its founding. In 2003, the premature flooding of the Senegal River prompted Senegalese authorities to take the initiative to open a breach in the coastal sand strip of the "*Langue de Barbarie*," in order to divert the water surplus from the river to the ocean and therefore resolve forever the problem of river flooding. But the disruption of estuarine dynamics has led to a rapid expansion of this gap: a few meters wide at its excavation, it reached over 2,700 m in August 2009. Moreover, 10 months after the widening of the gap, the old river mouth closed completely. If the natural movement of a mouth can be observed on some major deltas in the world (even on the Senegal River in the past), this can be considered a true man-made relocation. Based on the statistical analysis of series of hydrological data, this article demonstrates that climatic conditions in 2003 that generated a major flood was an anomaly detected in the sequence of dry climate variability observed in the Sahel. However, it also tracks the rapid evolution of this new mouth of the Senegal River and discusses some of impacts on the regional social–ecological system in this sensitive Sahelian environment.

Kharoufi, M. (1994). Forced migration in the Senegalese-Mauritanian conflict: Consequences for the Senegal River Valley. *Center for Migration Studies (special issues) 11(4)*, 140-155.

Khouma, M., Jalloh, A., et al. (2013). Senegal. West African agriculture and climate change: A comprehensive analysis. *IFPRI Research Monograph.* Jalloh, A., Nelson, G. C., Thomas, T. S.,

Zougmoré, R., and Roy-Macauley, H. Washington, DC, International Food Policy Research Institute, 291-322.

This book examines the food security threats facing 11 of the countries that make up West Africa--Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Liberia, Niger, Nigeria, Senegal, Sierra Leone, and Togo—and explores how climate change will increase the efforts needed to achieve sustainable food security throughout the region. West Africa's population is expected to grow at least through mid-century. The region will also see income growth. Both will put increased pressure on the natural resources needed to produce food, and climate change makes the challenges greater.

Koopman, J. (2012). Land grabs, government, peasant and civil society activism in the Senegal River Valley. *Review of African Political Economy, 39(134),* 655-664.

Following the Briefing in the last issue of *ROAPE*, this Debates contribution again uses Senegalese evidence to explore the interests and actions of major participants in the struggle to transform African agriculture: Government, national elites, peasants and their civil society allies. The first section examines government motivations in facilitating land grabs; the second reviews a seminal land grab case in the Senegal River Valley that illustrates the growing sophistication of the peasant pushback and the emergence of an anti-land grab coalition between civil society and peasant organizations.

Koopman, J. E. (2009). Globalization, gender, and poverty in the Senegal River Valley. *Feminist Economics, 15(3),* 253-285.

In an impressive attempt to guarantee food security, well over $2 billion have been invested in the modernization of the agrarian economy in the Senegal River Valley. But, even though two huge dams and thousands of village-based irrigation schemes have been constructed since the late 1970s, food security is still as elusive as ever. This study attempts to explain why. It focuses on the impact of donor-dominated macro-structural change on gender and class relations. This analytical perspective has two benefits: First, it reveals the risks posed by foreign domination of development programs for different segments of the rural population. Second, it points to a critical element in a new approach to improving farm productivity and food security—improving women's access to land and technology.

Lahtela, V. (2003). Managing the Senegal River: National and local development dilemma. *International Journal of Water Resources Development, 19(2),* 279-293.

The Senegal River is located in West Africa in the Sudano-Sahelian zone. The river has faced various development schemes since the early 1970s, which have not brought the desired results. Many problems stem from the overall lack of economic and human development and weak institutional settings. Droughts and ethnic complexities add to the problem. The environment and local population have continuously been exposed to negative changes. The river developers face a difficult task when choosing the development options for the future. Taking into account all the stakeholders and variables, and adding to these the external demographic and natural challenges, the development actions require weighing complex multiform and interconnected issues. An objective analysis of the development plans is needed in order to avoid repeating past mistakes and to acquire harmonious end results.

Lautze, J. & Kirshen, P. (2007). Dams, health, and livelihoods: Lessons from the Senegal, suggestions for Africa. *International Journal of River Basin Management, 5(3),* 199-206.

Efforts in previous decades, largely culminating in the release of the World Commission on Dams Report, have engendered a more circumspect approach to dam construction and

operations—one which incorporates consideration for the environment, health, equity, stakeholders, and livelihoods. Such integration nevertheless often remains at a rhetorical level, preventing tangible incorporation of these factors into Decision Support Tools (DSTs) for water management at a basin or sub-basin level. This paper uses the experience of the Senegal River Basin (SRB) to generate suggestions for how public health and smallholder livelihood concerns can be explicitly and quantitatively incorporated into dam planning and operations decisions in Africa's other basins. The study examines the operational tradeoffs made among livelihoods, health, and more conventional water needs such as irrigation and hydropower in SRB water management strategies over the last two decades. The examination of these tradeoffs is used to develop common health and economic metrics to aid water management decisions. In conclusion, suggestions are made for how utilization of these common metrics can enable DSTs in Africa's other basins to incorporate public health and smallholder livelihood parameters into dam planning and operations decisions.

Loftsdóttir, K. (2002). Knowing what to do in the city: WoDaaBe nomads and migrant workers in Niger. *Anthropology Today, 18(1),* 9-13.

Ly, C., Fall, A. et al. (2010). West Africa: The livestock sector in need of regional strategies. In: Gerber, P., Mooney, H. A., Dijkman, J., Tarawali, S., & de Haan, C. (eds), *Livestock in a Changing Landscape, Volume 2: Experiences and Regional Perspectives.* Washington, DC, Island Press: 27-54.

Most livestock in West Africa are kept in traditional smallholdings, in a large diversity of livestock and crop-livestock systems, in humid, subhumid, semiarid, and arid agroecological zones. There is a degree of interaction between livestock keepers and farmers right across these zones, which allows West Africa to be considered as an interdependent whole. These diverse livestock production systems are evolving. The path and rate at which they evolve are largely determined by the interaction of agroecological, social, economic, demographic, technological, and institutional factors. Changes are occurring in pastoral systems, crop-livestock systems, and stall-fed/intensive urban and periurban livestock production systems. Following a brief description of the livestock and crop-livestock farming systems of West Africa, this chapter provides a more detailed examination of the key drivers of change, followed by a discussion of the environmental, health, and social and economic consequences of the changes. The final section presents potential responses to the changes in terms of changing economic strategies, livestock policies, institutions, capacity building, and research.

Magistro, J., & Lo, M. (2001). Historical and human dimensions of climate variability and water resource constraint in the Senegal River Valley. *Climate Research, 19,* 133-147.

This paper provides a case study from the northern Senegal wetlands documenting trends in inter-annual and seasonal climate variability during the past century as well as human vulnerability and adaptation to anomalous climate events. A secular decline in precipitation during the past three decades has resulted in the construction of two dams on the Senegal River in the 1980s and an interstate river basin development strategy to develop hydroelectricity, irrigation farming, and a navigable waterway. Current agro-ecological production systems dependent on a seasonal riparian flood cycle could be curtailed in trying to meet these development objectives. Two hydrological time flow series illustrating the importance of inter-annual and seasonal climate variability for the region are used to weigh the costs and benefits of competing water use scenarios for end users.

Magistro, J. V. (1993). Crossing over: Ethinicity and Transboundary Conflict in the Senegal River Valley (*Ethnicité et conflit frontalier dans la vallée du fleuve Sénégal*). *Cahiers d'Études Africaines, 33(130),* 201-232.

Nombreuses sont les explications qui ont été avancées pour rendre compte du conflit qui a opposé le Sénégal et la Mauritanie en 1989. Cet article analyse l'interaction complexe des facteurs qui sont à l'origine de ce conflit: rivalités ethniques anciennes, relations entre États pendant et après la colonisation, effets délétères de la sécheresse sahélienne, ressentiment ethnique consécutif à l'émergence d'une identité nationale arabo-africaine, enjeux ethniques du contrôle des terres arables en Mauritanie. En combinant ces différents facteurs l'auteur propose un paradigme de ce conflit ethnique qui associe deux types d'interprétation: celle de Tambiah qui s'appuie sur une problématique matérialiste et structurale, et celle de Horowitz qui met l'accent sur la psychologie des acteurs. À l'occasion de ce conflit, des milliers de personnes ont été expulsées de Mauritanie et du Sénégal et ont perdu tous leurs biens. Les informations recueillies dans un village illustrent l'ampleur des pertes subies par une communauté de réfugiés de la rive gauche du fleuve Sénégal.

Matlon, P. J. (1991). Farmer risk management strategies: The case of the West African semi-arid tropics. *Risk in Agriculture. Proceedings of the Tenth Agriculture Sector Symposium*. Holden, D., Hazel, P., & Pritchard, A., 51-79.

A conceptual framework to identify and analyze the main risk management practices employed by farmers in the West African semiarid tropics is set out. Three sets of methods are examined by presenting comparative farm-level evidence of their application in the three major agroclimatic zones of the region. Data were collected by weekly household surveys in Burkina Faso during the period 1981-1985, among 150 farming households located in six villages in the three agroclimatic zones. The risk management methods differ in their application relative to the occurrence of production shocks. *Ex ante* methods (crop diversification, varietal diversification, and land-type diversification) are designed to place households in a less vulnerable position before the occurrence of a shock. Interactive methods involve the reallocation of resources at the time a shock occurs with the goal of minimizing its ultimate production impact. These methods consist of the adaptation of cropping patterns and cultivation practices during the cropping season. *Ex post* methods involve actions to obtain income after a shock has already reduced production to minimize the subsequent impact on consumption. Such sources of income include agricultural wage income, gifts, trading and artisanal activities, sale of livestock, migratory labor, and official food aid.

Mbow, C., Mertz, O., et al. (2008). The history of environmental change and adaptation in eastern Saloum–Senegal—Driving forces and perceptions. *Global and Planetary Change, 64(3-4),* 210-221.

Environmental change in the Sahel–Sudan zone of West Africa has been a major issue in development debates over the last decades. Using remote sensing based land cover change analysis, archival data, national and international statistical data, and household interviews, we analyze the drivers of environmental change in Eastern Saloum in Central East Senegal, as well as the local perceptions of these changes and adaptations. Being part of the ground nut basin, Eastern Saloum has witnessed rapid environmental degradation caused by the conversion of forest and savanna areas to agricultural land during the last 20–30 years and by a combination of decline in precipitation, soil degradation, a diversity of policies with little concern for the environment, fluctuating markets, and population pressure. Farmers perceive the environmental change mainly as land degradation and poor soil fertility, though recent extensification of agriculture counters this effect and has led to increased vegetation cover in marginal areas. They identified erratic climate, agricultural policies, insufficient food production, and desire to increase income as the main drivers of change in the area. The authors conclude that while

climate variability has influenced environmental change in the area, various types of State interventions in agriculture and global market fluctuations appear to have been the main underlying causes of environmental degradation.

McCartney, M., Rebelo, L.-M. et al. (2013). Agricultural water storage in an era of climate change: Assessing need and effectiveness in Africa. *IWMI Research Report 152.* Colombo, Sri Lanka, International Water Management Institute (IWMI).

By mitigating the vagaries of climatic variability, agricultural water storage is widely anticipated to make a key contribution to climate change adaptation, particularly in Africa. However, if the planning of water storage is not improved, it is likely that many investments will fail to deliver intended benefits. This report describes different agricultural water storage options and some of the possible implications of climate change. It also describes the development of a simple diagnostic tool that is based on a set of biophysical and demographic indicators and can be used to provide a rapid (first-cut) evaluation of the need and effectiveness of different water storage options under existing and possible future climate conditions. The tool was applied to sub-Saharan Africa and, in more detail, to the Volta Basin and the Ethiopian portion of the Blue Nile Basin. Throughout sub-Saharan Africa, the greatest need for storage was found in the Sahelian zone, the Horn of Africa, and southern Africa, with more localized hot spots in southern Angola, Rwanda, Burundi, and Uganda, as well as Malawi and Mozambique. In Ethiopia and Ghana, the greatest need was found not to be in areas with the least rainfall (as might have been anticipated), but rather in the areas with the highest population density. Based on changes anticipated by the realization of one downscaled 'middle impact' climate change scenario, the effectiveness of storage will decrease in both the Volta and Blue Nile basins in the future. The approach needs to be refined through further research and testing in real planning situations, but nevertheless provides the basis for a more rigorous approach to the planning of future agricultural water storage.

McIntire, J. (1991). Managing risk in African pastoralism. In: Holden, D., Hazel, P., Pritchard, A., (eds), *Risk in Agriculture. Proceedings of the Tenth Agriculture Sector Symposium,* 129-142.

Pastoral production systems face risks of exceptionally high magnitude. Producers have few alternatives to reduce those risks given the nature of the pastoral environment. Some of the externally proposed interventions to reduce risks include technical changes and changing herd management, credit, and price policies. Such development interventions, with the outstanding exception of veterinary care, have often produced low or negative returns. Simulations of a West African-type pastoral system indicate that the best risk management strategy is to sell stock in bad years and to withhold stock in good years. Even when this policy is complicated by price collapses brought about by higher sales levels, it is still superior to maintaining a target herd and to setting fixed offtake rates. The social costs of overgrazing appear to be less than the private benefits of maintaining larger herds.

Mertz, O., Mbow, C., et al. (2010). Climate factors play a limited role for past adaptation strategies in West Africa. *Ecology and Society, 15(4),* 25.

The Sudano-Sahelian zone of West Africa has experienced recurrent droughts since the mid-1970s, and today there is considerable concern for how this region will adapt to future climate change. To develop well-targeted adaptation strategies, the relative importance of climate factors as drivers of land use and livelihood change need to be better understood. Based on the perceptions of 1249 households in five countries across an annual rainfall gradient of 400-900 mm, we provide an estimate of the relative weight of climate factors as drivers of changes in rural households during the past 20 years. Climate factors, mainly inadequate rainfall, are perceived by 30-50 percent of households to be a cause of decreasing rain-fed crop production,

whereas a wide range of other factors explains the remaining 50-70 percent. Climate factors are much less important for decreasing livestock production and pasture areas. Increases in pasture are also observed and caused by improved tenure in the driest zone. Strategies for adaptation to declining crop production include 'prayer' and migration in the 400-500 mm zone; reforestation, migration, and government support in the 500-700 mm zone; and soil improvement in the 700-900 mm zone. Improved fodder resources and veterinary services counter declining livestock holdings. The conclusion of this work is that, although rain-fed crop production is mainly constrained by climate factors, livestock and pasture are less climate-sensitive in all rainfall zones. This information must be reflected in national adaptation strategies in the region.

Mertz, O., Mbow, C., et al. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management, 43(5),* 804-816.

Farmers in the Sahel have always faced climatic variability at intra- and inter-annual and decadal time scales. While coping and adaptation strategies have traditionally included crop diversification, mobility, livelihood diversification, and migration, singling out climate as a direct driver of changes is not so simple. Using focus group interviews and a household survey, this study analyzes the perceptions of climate change and sedentary farmers' strategies for coping and adaptation in the savanna zone of central Senegal. Households are aware of climate variability and identify wind and occasional excess rainfall as the most destructive climate factors. Households attribute poor livestock health, reduced crop yields, and a range of other problems to climate factors, especially wind. However, when questions on land use and livelihood change are not directly asked in a climate context, households and groups assign economic, political, and social rather than climate factors as the main reasons for change. It is concluded that the studied communities have a high awareness of climate issues, but climatic narratives are likely to influence responses when questions mention climate. Change in land use and livelihood strategies is driven by adaptation to a range of factors, of which climate appears not to be the most important. An implication of this work for policy-making for agricultural and economic development will be the need to provide flexible options rather than specific solutions for uncertain climate.

Mertz, O., Mbow, C., et al. (2011). Adaptation strategies and climate vulnerability in the Sudano-Sahelian region of West Africa. *Atmospheric Science Letters, 12(1),* 104-108.

Rural development in the Sudano-Sahelian region during the past 20 years and future scenarios of change were studied using meta-analysis of case studies, household interviews and scenario assessment. Households have generally increased their wealth, especially when they diversify out of agriculture. Rain-fed crop cultivation is more sensitive to climate factors than livestock, but generally climate factors play a limited direct role for local land use and livelihood strategies. The agricultural sector needs strong support to remain important in the region and off-farm work and migration are likely to continue to increase, which may decrease vulnerability.

Miehe, S., Kluge, J., et al. (2010). Long-term degradation of Sahelian rangeland detected by 27 years of field study in Senegal. *Journal of Applied Ecology, 47(3),* 692-700.

A summary of this work follows:

1. Sustainable management of rangelands will become increasingly important as climate changes, but rangeland dynamics are still a challenge to dryland ecologists because degradation patterns are difficult to sample and interpret. There are contradictions between remote sensing-based studies and field-based analyses, for which long-term data are almost nonexistent. In the rangelands of North Senegal, remote sensing studies have not revealed

any extensive degradation during the past three decades. The present study used a 27-year series of field data from the area to assess the impact of grazing on rangeland degradability.

2. Rainfall, standing crop, and floristic data from North Senegal were analyzed to quantify the effects of rainfall patterns and grazing on plant composition and the overall rain use efficiency. Monitoring plots of 1 ha comprised five ungrazed and 19 grazed plots with two different grazing treatments. Standing crop was sampled annually at the peak of biomass development. Data were analyzed with mixed effect models.

3. Changes in herbaceous production were mainly caused by fluctuations in rainfall, whereas the grazing intensity had a long-term effect, interacting with precipitation dynamics. During the first and drier phase, rainfall variability masked the grazing influence, whereas during the second phase with above-average rainfall, grazing treatments differed significantly, indicating rangeland degradation.

4. The patterns of productivity and floristic composition followed predominant non-equilibrium dynamics during the first phase (rainfall variability 40 percent), whereas gradual changes especially in species composition represented characteristics of equilibrium systems during the second phase (rainfall variability 23 percent). Thus, the study supports the existence of shifts between periods of non-equilibrium conditions and those more typical of equilibrium systems.

5. This 27-year field study, carried out with the aim of assessing the non-degradability of Sahelian rangelands, revealed long-term degradation trends linked to grazing intensity. Longer observation periods provide an increasing probability of including 'equilibrium phases' that allow the identification of long-term degradation processes. Consequently, both rangeland research and management policies demand monitoring periods that are long enough to account for long-term trends. The grazing experiment in this study has shown that degradation processes are reversible, but long-term exclosure and ranching with fixed stocking rates are less suitable for rangeland amelioration than moderate, production-adjusted grazing regimes mimicking traditional nomadic systems.

Moritz, M., Kyle, B. R., et al. (2009). Too many people and too few livestock in West Africa? An evaluation of Sandford's thesis. *The Journal of Development Studies, 45(7),* 1113-1133.

This work examines whether Stephen Sandford's (2006b) "too many people, too few livestock" thesis for the Greater Horn of Africa applies to West Africa. In a comparative study of seven pastoral systems across West Africa, these authors found that pastoralists generally have successfully adapted to pressures on grazing resources. The authors describe three adaptive strategies: 1) integration and intensification in the Sudanian zone; 2) movement to the Sub-Humid zone; and 3) extensification in the Sahelian zone. They end by proposing four interrelated factors that account for the differences in pastoral systems between West Africa and the Greater Horn of Africa.

Mwangi, E. & Dohrn, S. (2008). Securing access to drylands resources for multiple users in Africa: A review of recent research. *Land Use Policy, 25(2),* 240-248.

This review discusses persistent tensions in efforts to secure land rights in Africa's drylands. Some researchers and practitioners advocate for formal, legal recognition of group rights as a way to secure access for drylands resource users. Others, on the other hand, speak against formal, legal protections. They argue that much of Africa's drylands are collectively held, often under customary tenures. Statutory law may undermine the dynamism, flexibility, and inclusiveness of such tenures. By reviewing innovative efforts to secure access in different parts

of Africa, the paper shows that any attempt to secure access for multiple users in drylands environments needs to identify frameworks for negotiated conflict resolution, crafting rules from the ground upwards, in addition to a more generic identification of rights. Policy-makers can thus focus on process, as well as the content of tenure arrangements, reconciling statutory rights with customary rights. For rights to be meaningfully secured, however, there is a need to identify the nature and sources of threats that create insecurities and to tailor policy solutions to threats. Elite capture and exclusion of women and young people continue to pose significant challenges in such decentralized processes.

N'Diaye, E., Bouvier, A.-L., et al. (2007). Dam construction in the Senegal river valley and the long-term socioeconomic effects. *Knowledge, Technology, and Policy, 19(4),* 44-60.

Nation, M. L. (2010). Understanding women's participation in irrigated agriculture: A case study from Senegal. *Agriculture and Human Values, 27(2),* 163-176.

As climate change in West Africa places profound limitations on rain-fed agriculture, policymakers and practitioners may again turn to irrigated agriculture to provide food for a growing population. Gendered analyses of irrigation projects reveal that women's participation in irrigated agriculture in many cases has been limited due to a lack of access to land and water. Past research in the Upper Valley of the Senegal River suggests that variables other than access to land and water condition women's participation in irrigated agriculture. Fully understanding women's participation in irrigated agriculture demands examination of intra-household dynamics and livelihood strategies as well as the impacts of agricultural commodification.

Ndiaye, O., Moussa, A., et al. (2013). Communicating seasonal forecasts to farmers in Kaffrine, Senegal, for better agricultural management. Case Study. *Hunger, Nutrition, Climate Justice 2013. A New Dialogue: Putting People at the Heart of Global Development.* Dublin, Ireland: Irish Aid.

Park, T. K., Ed. (1993). *Risk and Tenure in Arid Lands: The Political Ecology of Development in the Senegal River Basin.* Tucson & London: University of Arizona Press.

Parton, W., Tappan, G., et al. (2004). Ecological impact of historical and future land-use patterns in Senegal. *Journal of Arid Environments, 59(3),* 605-623.

The CENTURY model was used to simulate changes in total system carbon resulting from land-use history (1850–2000), as well as impacts of climatic changes and improved land-use management practices in Senegal. Results show that 0.477 Gtons of carbon have been lost from 1850 to 2000. Improved management practices have the potential to increase carbon levels by 0.116 Gtons from 2000 to 2100. Potential to store carbon exists for improved forest management and agriculture practices in southern Senegal. Potential climatic changes decrease plant production (30 percent), total system carbon (14 percent), and the potential to store carbon from improved management practices (31 percent).

Picquet, M., Ernould, J. C., et al. (1996). The epidemiology of human schistosomiasis in the Senegal river basin. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 90(4),* 340-346.

Extensive water development has taken place in the north of Senegal over the past decade, resulting in a large increase in the amount of fresh water for irrigation. The objectives of the present study were to determine the prevalence and intensity of Schistosoma mansoni and S. haematobium in the Senegal river basin (SRB), and to ascertain the distribution of the snail species acting as intermediate hosts for both species of schistosomes. The schistosomiasis survey started in January 1994 and was completed in March 1995. Compared to studies before the construction of the Diama dam, there was a significant increase in both the prevalence and intensity of urinary and intestinal schistosomiasis in the human population in parts of the SRB.

From the 9,014 people who were registered from 180 villages and four towns (10 districts), 7,750 were examined. S. mansoni was found in the lower valley (lower delta-Senegal river, lower delta-Lampsar river, upper delta, and diéré) but not in the middle valley. The mean prevalence ranged from 4.4 percent in the lower delta-Senegal River to 71.8 percent in the zone of Lac de Guiers, where prevalence and intensity of infection were higher on the eastern side of the lake (81.3 percent with a mean number of 2088 eggs/g of feces) compared with the western side (50.3 percent with a mean 1111 eggs/g). S. haematobium was recorded throughout the area of study, ranging from a mean prevalence of 0.37 percent in diére (lower valley) to 41.5 percent in the lower valley (Lampsar river), where the mean egg count was 313/10 mL of urine. Physical and chemical changes to the environment have favored the spread and increase in the populations of freshwater snails. The only snail involved in the transmission of S. mansoni was Biomphalaria pfeifferi. Five species of bulinid snails were present — Bulinus globosus, Bu. umbilicatus, Bu. senegalensis, Bu. forskalii, and Bu. Truncates — but only the first three species were involved in the transmission of S. haematobium in the lower and middle valleys.

Pires, M. (2012). A historical political ecology of land use in the southeastern Peanut Basin of Senegal. *African Geographical Review, 31(2),* 95-110.

This article presents a history of 20th century human occupation and agricultural expansion in the southeastern Peanut Basin in Senegal, West Africa. Using a political ecology conceptual framework, the author describes social and cultural characteristics of the region's population relevant to an analysis of environmental challenges that have affected the region over time. The author also addresses the significance of state intervention, during both colonial and post-colonial times, in agricultural resettlement schemes that were intended to control access to land-based resources in this less densely populated part of the country. A discussion of more recent studies on environmental change and land-use in the Peanut Basin illustrates the importance of understanding the region's past in order to address its contemporary environmental challenges. This examination of historical land-use dynamics in the southeastern Peanut Basin informs current conditions and future concerns regarding natural resource management in the region.

Powell, J. M., Pearson, R. A., et al. (2004). Crop–livestock interactions in the West African drylands. *Agronomy Journal, 96(2),* 469-483.

Many semiarid regions of Sub-Saharan Africa (SSA) are experiencing vast increases in human population pressure and urbanization. These augment the demand for agricultural products and have led to the expansion, intensification, and often closer integration of crop and livestock production systems. The transition of crop and livestock production from the current relatively extensive, low input/output modes of production to more intensive, higher input/output modes of production presents numerous challenges to the achievement of required long-term production increases from these farming systems. This paper provides an overview of the challenges facing agricultural production in semiarid SSA with a focus on West Africa. A description of mixed crop–livestock farming systems and their evolution is followed by an overview of the principal linkages between crops and livestock: income, animal power, feed, and manure. The most detailed discussions relate to nutrient cycling in these farming systems. Most livestock derive their feed almost exclusively from natural rangeland and crop residues, and livestock manure is a precious soil fertility amendment; however, most farmers have insufficient livestock and therefore manure to sustain food production. Nutrient harvests from cropland often exceed nutrient inputs, and soil nutrient depletion is a principal concern. The paper concludes with a discussion of strategies that may improve the productive capacity of these mixed farming systems.

Population Reference Bureau (2012). 2012 World Population Data Sheet. Available at: http://www.prb.org/Publications/Datasheets/2012/world-population-data-sheet.aspx

Rankins, J., Sathe, S. K., et al. (2008). Solar drying of mangoes: Preservation of an important source of vitamin A in French-speaking West Africa. *Journal of the American Dietetic Association, 108(6),* 986-990.

Vitamin A deficiency, which is especially widespread among children younger than five years old, is a major barrier to reducing child mortality rates in French-speaking West Africa. A large amount of an indigenous plant source of provitamin A carotenoids are lost to postharvest waste. For example, the postharvest loss of mangoes in the region exceeds an annual total of 100,000 metric tons. In our study, 3.75 metric tons of fresh mangoes were dried using a solar dryer to a final moisture content of 10 percent to 12 percent, yielding a total of 360 kg dried mango. The product analysis revealed 4,000±500 μg beta carotene/100 g and 3,680±150 μg beta carotene/100 g after two and six months of storage, respectively. Thus, one greenhouse solar dryer is capable of reducing postharvest mango waste by 3.75 tons, providing up to 1.15 million retinol activity equivalents of dietary vitamin A. The use of this technology that requires solar energy and manpower has the potential to increase dietary vitamin A supply by up to 27,000-fold as compared to the currently available vitamin A in the region. Moreover, the population in this geographic area likes mango, increasing the likelihood of its ready acceptance. Reducing postharvest loss of mangoes by using greenhouse model solar dryers is a promising strategy to help combat vitamin A deficiency in French-speaking West Africa.

Rasmussen, K., Larsen, N., et al. (1999). Agricultural systems and transnational water management in the Senegal River basin. *GeografiskTidsskrift—Danish Journal of Geography, 99,* 59-68.

This paper examines the relationship between hydrology and the functioning of traditional and modem agricultural systems in the Senegal River valley in West Africa. The traditional flood recession agriculture, relying on the natural flooding of the wide river valley, is declining because of a strong reduction of the inundated area. This situation is due to both the reduction in rainfall since the early 1970s and the construction of the Manantali Dam, controlling the discharge in the Bafm branch of the river. The operation of the dam is presently optimized to satisfy the needs of modem irrigated rice cultivation, but the development of this cultivation has not entirely lived up to expectations mainly because of economical and management problems. Therefore, farmers still express a preference for flood recession agriculture whenever the floodings are sufficiently large. In the future, water availability for both the flood recession and irrigated agriculture will be influenced by two major projects. Firstly, there is a plan to initiate hydro-electric power production at Manantali, which will change the principles of dam operation. Secondly, there is a plan to dam the Faleme branch of the Senegal River to divert water into the dry 'fossil' valley system in northern-central Senegal. This paper argues that hydrological modelling coupled with an economic assessment of costs and benefits of all the effects, including the environmental impacts, are necessary in the decision-making process concerning major projects that affect water availability and management in major transnational river basins such as the Senegal River basin.

Roe, E., Huntsinger, L., et al. (1998). High reliability pastoralism. *Journal of Arid Environments, 39(1),* 39-55.

In contrast to the view of pastoralism as being driven by risk aversion, new disequilibrium-based models of ecological dynamics on rangelands enable us to see pastoralism as what organization theorists term a high reliability institution. Such institutions seek and attain reliable peak performance by managing highly complex technologies to better manage risk. Nine features of high-reliability organizations are described and linked to published observations of pastoralist organization and practice. Although superficially similar, thinking of pastoralist objectives in

terms of searching for reliability, rather than escaping from hazard, has important implications for interpreting pastoralist behavior and for development policy.

Roncoli, C., Ingram, K., et al. (2001). The costs and risks of coping with drought: Livelihood impacts and farmers' responses in Burkina Faso. *Climate Research, 19(2),* 119-132.

This paper analyzes the responses enacted by families of the Central Plateau in Burkina Faso during the year that followed a severe drought in 1997. Authors illustrate the agro-ecological and socioeconomic contexts that shape livelihood options and constraints in an area characterized by high levels of climatic risk and low natural resource endowment. A description of farmers' perceptions and official accounts identifies key criteria whereby farmers formulate evaluations and predictions of a season. They document how food procurement and management practices are shaped by household resource access profiles and livelihood portfolios. Livelihood diversification, encompassing migration, non-farm work, and social support networks, in addition to livestock production, is shown to be a critical dimension of adaptation. Livelihood and production adjustments entail costs and risks for most, but also gains for those who have the resources needed to take advantage of distress sales and high prices of agricultural commodities. Household livelihood and risk management increasingly hinge on efforts by household members who traditionally have had marginal access to resources, especially women. The research points to the need for closer integration of drought preparedness efforts, farmers' understanding of climate-crop interactions, and interventions that bolster the capacity of resource-limited households to respond. Affordable grain, locally adapted seed varieties, labor-saving technology, and flexible credit are among the most needed inputs.

Saarnak, N. L. (2003). Flood recession agriculture in the Senegal River Valley. *Geografisk Tidsskrift–Danish Journal of Geography, 103(1),* 99-113.

The purpose of this paper is to explore the system dynamics, the importance, and the future of the low-yielding flood recession farming system as practiced in the Senegal River Valley. This information is discussed in relation to the introduction of irrigated agriculture into villages of the valley and to the hydrological changes of the Senegal River caused by the construction of the Manantali dam and the Sahelian drought of the 1970s and 1980s. The paper is based on data collected during three months of fieldwork in three villages located in the Podor region in Senegal. The fieldwork focused on the physical and ecological aspects of the flood recession farming system. Data was obtained through semi-structured interviews on the household level and with groups of village elders and local agricultural leaders. On the regional and national level, interviews were carried out with the agricultural and water management authorities.

The flood recession farming system is based on natural irrigation and fertilization of the flood plain. Sorghum, beans, and melons are cultivated on the remaining soil moisture from the yearly inundations of the river valley in August and September. Flood recession farming receives no controllable input other than land and labor and therefore has a very high net return to energy expenditures. The study, however, shows that the labor productivity and the net income from the input-intensive irrigated farming system far exceed that of the traditional flood recession farming. Nevertheless, the output from the recession farming is very important to household subsistence, because the general energy requirements of the households are far from covered by irrigated farming. The recession agriculture would then support household subsistence during months where other contributions to household subsistence are limited. Furthermore, results of recession farming are strongly affected by the limited flooding that prevailed during the investigated period.

The management of the Manantali dam in Mali and the varying precipitation in the upper part of the river basin cause large yearly variations in river valley inundations and thus affect the yield

from recession farming. Since farmers cannot control the access of river water to the recession fields, there exists no incentive for the farmer to invest in the development of a flood recession farming system. If the system is not further developed, the potential for recession agriculture is likely to decrease as population and subsistence demands increase and irrigated agriculture is further developed. Therefore, the future of flood recession agriculture depends in large part on the willingness of the dam management authorities to ensure a yearly and stable inundation of recession land in years of limited natural flows. This approach would eliminate the insecurity of water availability and justify investments in, and further development of, traditional farming practices.

Salem-Murdock, M. (1987). Hunger and river basin development in Africa: Some socioeconomic issues. *GeoJournal, 14(1),* 37-47.

New concerns with African drought and famine have redirected attention to the great potential of African rivers to increase food production dramatically. The recent history of irrigation, however, has proved otherwise, partly due to policy makers' systematic failure to consider the socioeconomics of land/water use in river basins in their development plans. This paper focuses on the socioeconomic dimensions of African river basin development and argues that a better incorporation of such systems in development plans will aid African countries to achieve their food production and development goals more effectively.

Sall, M. (2010). Straightforward critics or would-be candidates? International migrants and the management of local affairs and development: The case of the Senegal River valley. *Environment and Urbanization, 22(1),* 81-89.

The Senegal River valley has long been one of the main sources of out-migration to international destinations in the country, and migrants' remittances are important for the survival of households and for economic and social development of the area. Investments in home towns and a highly critical view of the ways in which local affairs are managed encourage migrants' active involvement in local development through associations and, increasingly, in local politics. This paper describes these processes in the light of decentralization in Senegal, especially the transfer of authority to manage the use of state and public lands to local government.

Scheffran, J., Marmer, E., et al. (2012). Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in Northwest Africa. *Applied Geography, 33(0),* 119-127.

Human migration has been described as one of the conflict constellations in regions affected by climate change, but it can also contribute to climate adaptation. Migrant social networks can help build social capital to increase social resilience in communities of origin and trigger innovations across regions by the transfer of knowledge, technology, remittances, and other resources. These transfers could increase the flexibility, diversity, and creativity of communities in addressing climate stress as well as open new pathways for co-development connecting the home and host communities. Based on a conceptual framework connecting migration and adaptation, the paper explores possible opportunities, innovative approaches, and institutional mechanisms for migration as a contribution to climate adaptation. The Western Sahel is used as a case study region, with a focus on Mali, Mauritania, and Senegal, using qualitative and quantitative analysis of remittances at the national level as well as a micro-level analysis on the role of migrant networks in these countries in specific co-development projects in water, food, and energy.

Sissoko, K., van Keulen, H., et al. (2011). Agriculture, livelihoods and climate change in the West African Sahel. *Regional Environmental Change, 11,* 119-125.

The West African Sahel is a harsh environment stressed by a fast-growing population and increasing pressure on the scarce natural resources. Agriculture is the main source of livelihood of the majority of the people living in the area. Increases in temperature and/or modifications in rainfall quantities and distribution will substantially impact the natural resource on which agriculture depends. The vulnerability of livelihoods based on agriculture is increased and most likely will exacerbate and accelerate the current 'downward spiral' of underdevelopment, poverty, and environmental degradation. Notably droughts, a short rainy season, and/or very low rainfall will be felt by current systems. To cope with the difficult climatic situation, farm households have developed a range of strategies including selling animals and on-farm diversification or specialization. At the regional level, early warning systems including an operational agro-meteorological information system already provide farmers with crucial information. Substantial political, institutional, and financial efforts at the national and international level are indispensable for the sustenance of millions of lives. In terms of development, priority must be given to adaptation and implementation of comprehensive programs on water management and irrigation, desertification control, development of alternative sources of energy, and the promotion of sustainable agricultural practices by farmers.

Sutter, J. W. (1987). Cattle and inequality: Herd size differences and pastoral production among the Fulani of northeastern Senegal. *Africa, 57(02),* 196-218.

There is a growing body of research that addresses issues of income distribution and the mechanisms of inequality in rural farming communities in Africa (see, for example, Hill, 1972; Matlon, 1981; Kitching, 1980; Sutter, 1981; Watts, 1983). Unfortunately, recognition of the importance of economic inequality in African societies dependent on animal husbandry has lagged. Much of the research on pastoral systems of production of the past several decades has been carried out by anthropologists whose work, to the extent that it addresses issues of economic heterogeneity at all, has emphasized the types of 'levelling' and 'adaptive' mechanisms common to pastoral systems. Recurrent issues of focus have been the ideology of equality that tends to predominate in pastoral societies, the limited development of political hierarchies, the limitations on herd size imposed by family labor and ecology, the wide-spread transfer of assets at critical moments in the life cycle, and the apparent similarities in consumption levels of different households (see, for example, Barth, 1961; Goldschmidt, 1971; Dahl, 1979a; Schneider, 1979).

Swift, J. (1977). Sahelian pastoralists: Underdevelopment, desertification, and famine. *Annual Review of Anthropology, 6,* 457-478.

A large number of fields of study are relevant to the genesis of the Sahel famine of 1968-1973. This author focused this review on three issues: (a) some aspects of the Sahelian pastoral economy and its relation to wider market economies; (b) the demography of Sahelian pastoralists; and (c) changes in the past half century, from the imposition of French colonial rule. Hard information is scarce in all these fields, so it is hazardous to theorize; but without some attempt at explanation of the recent events in terms more satisfactory than "population growth" or "climate change," little progress can be made. The author has not drawn specific development policy conclusions, preferring to let the historical record speak for itself.

Tabor, J. A. (1995). Improving crop yields in the Sahel by means of water-harvesting. *Journal of Arid Environments, 30(1),* 83-106.

Agricultural water-harvesting systems provide spectacular results throughout the Sahel, but their application is much less widespread than is possible. Constraints on and opportunities for their use are discussed here, with specific examples drawn from a yield study conducted in Niger. The high millet (*Pennisetum americanum* [L] K. Schum) and sorghum (*Sorghum bicolor* [L]

Moench) yields achieved with micro-catchment water harvesting show it as a promising cropping system for land-poor farmers and/or in areas where conventional practices produce relatively low yields.

Tall, A., Mason, S. J., et al. (2012). Using Seasonal Climate Forecasts to Guide Disaster Management: The Red Cross Experience during the 2008 West Africa Floods. *International Journal of Geophysics, 2012,* 12.

In 2008, the seasonal forecast issued at the Seasonal Climate Outlook Forum for West Africa announced a high risk of above-normal rainfall for the July–September rainy season. With probabilities for above-normal rainfall of 0.45, this forecast indicated noteworthy increases in the risk of heavy rainfall. When this information reached the International Federation of Red Cross and Red Crescent Societies (IFRC) West and Central Africa Office, it led to significant changes in the organization's flood response operations. The IFRC regional office requested funds in advance of anticipated floods, prepositioned disaster relief items in strategic locations across West Africa to benefit up to 9,500 families, updated its flood contingency plans, and alerted vulnerable communities and decision-makers across the region. This forecast-based preparedness resulted in a decrease in the number of lives, property, and livelihoods lost to floods; just one year prior in 2007, similar floods claimed more than 300 lives in the region. This article demonstrates how a science-based early warning informed decisions and saved lives by triggering action in anticipation of forecast events. The article analyzes what it took to move decision-makers to action based on seasonal climate information, and to overcome traditional barriers to the uptake of seasonal climate information in the region, providing evidence that these barriers can be overcome. While some institutional, communication, and technical barriers were addressed in 2008, many challenges remain. Scientists and humanitarians need to build more common ground.

Tappan, G. G., Sall, M., et al. (2004). Ecoregions and land cover trends in Senegal. *Journal of Arid Environments, 59(3),* 427-462.

This study examines long-term changes in Senegal's natural resources. Authors monitor and quantify land use and land cover changes occurring across Senegal using nearly 40 years of satellite imagery, aerial surveys, and fieldwork. They stratify Senegal into ecological regions and present land-use and land-cover trends for each region, followed by a national summary. Results aggregated to the national level show moderate change, with a modest decrease in savannas from 74 to 70 percent from 1965 to 2000, and an expansion of cropland from 17 to 21 percent. However, at the ecoregion scale, the authors observed rapid change in some and relative stability in others. One particular concern is the decline in Senegal's bio diverse forests. However, in the year 2000, Senegal's savannas, woodlands, and forests still cover more than two-thirds of the country, and the rate of agricultural expansion has slowed.

Touré, I. (2012). Autonomy and local democracy in Africa: An illustration using the case of Senegal. *International Review of Administrative Sciences, 78(4),* 757-774.

From a retrospective and synchronous perspective, this work analyzes the often conflicting power relations between the French colonial administration, the Senegalese post-colonial central states, and the decentralized collectivities. Reflecting on the effective autonomy of the local collectivities in the management and running of the competences transferred to them through decentralization laws, the article shows how, on the basis of real cases, the intervention of central power in local affairs not only questions democracy but also diverts regionalization policies from their initial objectives.

This article is a reference tool for understanding the history and evolution of decentralization in

Senegal. By examining several questions, it supplies evidence on the functioning of decentralized communities, local governance, land management, and the system of financial adjustment. It proposes means of decision-making and useful actions for those who are interested in the feasibility of democracy and local development in Senegal.

Toure, O. (1988). The pastoral environment of northern Senegal. *Review of African Political Economy, 15(42),* 32-39.

In this article, Toure catalogues a century of change in the nomadic way of life brought about by French colonialism and capitalism. He describes the transformation of the Peul, who farmed and herded a variety of animals in a system of long-distance transhumance into permanently settled cattle ranchers. As the long drought made clear, the environmental consequences are disastrous. The human consequences are more mixed. This article raises interesting questions about class differentiation and changes in women's responsibilities: do boreholes reduce the work of water carrying, and do larger herds increase the work of milking and making butter?

Tschakert, P. (2007). Views from the vulnerable: Understanding climatic and other stressors in the Sahel. *Global Environmental Change, 17(3–4),* 381-396.

In much of sub-Saharan Africa, considerable research exists on the impacts of climate change on social-ecological systems. Recent adaptation studies emphasize sectoral vulnerability and largely physical adaptation strategies that mirror anti-desertification plans. The adaptive role of subsistence farmers, the vulnerable 'target' population, is largely overlooked. This article aims to fill this gap by focusing on views from the vulnerable. Drawing from participatory risk ranking and scoring among smallholders in central Senegal, data on multiple hazards indicate that farmers' adaptive capacity in the face of climate change is undermined by poor health, rural unemployment, and inadequate village infrastructure. Results from conceptual mapping reveal an incomplete understanding of causes and consequences of climate change; however, shared knowledge and lessons learned from previous climatic stresses provide vital entry points for social learning and enhanced adaptive capacity to both wetter and drier periods now and in the future.

Tschakert, P., Sagoe, R., et al. (2010). Floods in the Sahel: An analysis of anomalies, memory, and anticipatory learning. *Climatic Change, 103(3-4),* 471-502.

This study explores the implications of recent extreme rainfall and flood events in the Sahel and the wider West African region for climate change adaptation. Are these events merely a temporal nuisance as suggested by the lingering desertification discourse, or will more climatic extremes characterize the region over the next century? After reviewing incidences of severe rainfall and projected future climate variability, the paper examines local flood knowledge and decision-making, drawing upon a case study in Ghana. The data demonstrate that a variety of response strategies to flooding exist, but knowledge of and access to climate forecasts and other learning tools are essentially absent. So far, floods have not triggered mass displacement, but cumulative environmental deterioration is likely to cause environmental refugees. The paper recommends that we lay to rest the desertification narrative, consider the possibility of both floods and droughts, and mobilize local memory for anticipatory learning and practical adaptation.

Turner, M. (1993). Overstocking the range: A critical analysis of the environmental science of Sahelian pastoralism. *Economic Geography, 69(4),* 402-421.

There has been little experimental work in West Africa that distinguishes grazing from climate effects on rangeland vegetation. In the absence of such knowledge, the recurrence of boom-bust

cycles in livestock populations, along with the seemingly degraded state of semiarid range, have been used to support notions of the inevitability of overgrazing. Regional stocking rates are used as indicators of degradation potential. The author argues that environmental analysts' persistent reliance on carrying-capacity models oversimplifies range ecology and excludes social processes from causal analyses. Both regional stocking rates and the seasonality of livestock distributions should be treated as proximate factors, each affected by biophysical and socioeconomic conditions. The common assumption that the size of local livestock populations is primarily affected by bioclimatic factors results from a misunderstanding of the pastoral economy. A case study examines the underlying causes of the cattle population boom in the Maasina during the 1960s. Rather than being solely a biological phenomenon, growth in the Maasina cattle population resulted from the historical confluence of inoculation programs with greater local demand for covert accumulation brought about by the changing social relations between the Fulβ e and the Rimayβ e.

Turner, M. D. (2011). The new pastoral development paradigm: Engaging the realities of property institutions and livestock mobility in dryland Africa. *Society & Natural Resources, 24(5),* 469-484.

The confluence of new understandings of dryland ecology and common property resource management has arguably led to a "new pastoral development paradigm" – a paradigm that incorporates a widespread acceptance of the importance of livestock mobility within the context of devolving greater rangeland management authority to local groups. Despite more than a decade of interest and attention generated by this new paradigm, little progress has been achieved on the ground. A major premise of this article is that this impasse results from persistent conceptual difficulties surrounding the relationship between livestock mobility, nonequilibrium ecology, and common property institutions. These difficulties are best resolved through work grounded in the social and ecological realities of particular regions. The promise of such engagements is illustrated through case material from the annual grasslands of the Sahelian region of West Africa. Finally, the paper presents policy implications resulting from a reconceptualization of the relationship between property and dryland ecology.

van Houweling, E., Hall, R. P., et al. (2012). The role of productive water use in women's livelihoods: Evidence from rural Senegal. *Water Alternatives, 5(3),* 658-677.

Enhancing livelihoods and promoting gender equity are primary goals of rural development programs in Africa. This article explores the role of productive water use in relation to these goals based on 1860 household surveys and 15 women's focus groups conducted in four regions of Senegal with small-scale piped water systems. The piped systems can be considered 'domestic plus' systems because they were primarily designed for domestic use. They also accommodate small-scale productive uses, including livestock-raising and community-gardening. This research focuses on the significance of productive water use in the livelihood diversification strategies of rural women. In Senegal, the authors find that access to water for productive purposes is a critical asset for expanding and diversifying rural livelihoods. The time savings associated with small piped systems and the increase in available water allowed women to enhance existing activities and initiate new enterprises. Women's livelihoods were found to depend on productive use activities, namely livestock-raising and gardening. It is estimated that one half of women's incomes is linked to productive water use. While these findings are largely positive, the authors find that water service and affordability constraints limit the potential benefits of productive water use for women and the poorest groups. The authors discuss implications for targeting women and the poorest groups within the domestic-plus approach.

Venema, H. D., Schiller, E. J., et al. (1997). A water resources planning response to climate change in the Senegal River Basin. *Journal of Environmental Management, 49(1),* 125-155.

Venema, H. D., Schiller, E. J., et al. (1996). Factor biases and promoting sustainable development: Adaptation to drought in the Senegal River Basin. *Mitigation and Adaptation Strategies for Global Change, 1(2),* 139-165.

The ongoing drought in the Sahel region of West Africa highlights the vulnerability of food-producing systems to climate change and variability; therefore, adaptation to climate should increase the sustainability of agriculture under a long-term drought. Progress toward sustainability and adaptation in the Senegal River Basin is hampered by an existing set of social and ecological relationships that define the control over the means of production and how people interact with their environment. These relationships are sensitive to the technological inputs and the administration of food production, or the factor bias in the different policy alternatives for rural development. One option is based on state-controlled, irrigated plantations that would provide rice (Oryza) for the capital, Dakar. This policy emphasizes a top-down management approach, mechanized agriculture, and a reliance on external inputs that strengthens the relationships introduced during the colonial period.

A time-series decomposition of the annual flow in the Senegal River at Bakel in Senegal suggests that water resources availability has been substantially curtailed since 1960, and a review of the water resources budget or availability in the basin suggests that this policy's food production system is not sustainable under the current climate of the basin. Under these conditions, this program exacerbates existing problems of landscape degradation and desertification, which increases rural poverty. A natural resource management policy offers two adaptation strategies that favor decentralized management and a reduction of external inputs. The first alternative, "Les Perimetres Irrigués," emphasizes village-scale irrigation, low water consumption cereal crops, and traditional socio-political structures. The second alternative emphasizes farm-level irrigation and agro-forestry projects to remedy the primary effects of desertification.

The water requirements of both the rice import substitution program and the natural resource management program are calculated. A water resources simulation model/optimization analysis using dynamic programming is used to compare these two alternatives to the rice import substitution programs. Results indicate that the natural resource management policy could potentially bring a large area into production while using far less water than the rice import substitution program. The natural resource management policy, in particular the second alternative with its emphasis on individual ownership and ecological rehabilitation, defines a different set of social and ecological relationships that appear to enhance the sustainability of food production under a long-term drought.

Wane, A., Ancey, V., et al. (2010). *Pastoralisme et recours aux marchés: Cas du Sahel sénégalais* (Ferlo). (Sahelian herders and the markets: Evidence from the Senegalese Sahel [Ferlo]). *Cahiers Agricultures, 19(1),* 14-20.

Souvent perçus comme des êtres contemplatifs non économiques, les pasteurs commercialisent néanmoins leurs produits sur les marchés. Leur principal motif de vente est de dégager des recettes permettant de couvrir leurs dépenses courantes et assurer leur sécurité alimentaire. Au terme d'une enquête sur cinq sites du Ferlo entre la saison des pluies 2005 et celle de 2006, une étude détaillée des ventes des pasteurs montre que la présence de forages, souvent considérée comme élément structurant de l'activité pastorale, n'accroît pas systématiquement les ventes de produits pastoraux. Les recettes sont tirées essentiellement de la commercialisation d'animaux de rente (97,9% des ventes globales dont bovins à 40%, petits ruminants à 60%). Les ventes de produits laitiers (lait frais et caillé, beurre) restent marginales (0,50%) et inversement liées au degré d'enclavement des lieux de résidence et d'activité des pasteurs. La diversification observée dans les productions et dans les activités ne se traduit pas dans la commercialisation. Les concepts de pauvreté, de vulnérabilité, de fourniture de services sociaux de base,

sont repensés en fonction des caractéristiques du pastoralisme en zones arides (mobilité, éclatement des familles, dispersion de l'habitat).

Often perceived as non-economic contemplative beings, pastoralists still market their products in the markets. Their main reason for selling livestock and animal products is to generate revenue to cover their usual expenses and ensure their food security. After a survey of five sites in Ferlo between the rainy season in 2005 and the 2006, a detailed study of sales by pastoralists shows that the presence of borehole wells, often seen as a structuring element of pastoral activity, does not systematically increase sales of livestock products. The incomes are mostly drawn from the livestock marketing (97.9 percent of total sales, with cattle contributing 40 percent and small ruminants contributing 60 percent). Sales of dairy products (milk and fresh curd, butter) are marginal (0.50 percent) and inversely related to the degree of isolation of herders' places of residence and activity. The diversification observed in production and activities is not reflected in the market. The concepts of poverty, vulnerability, and providing basic social services are reconsidered according to the characteristics of pastoralism in arid areas (mobility, family breakdown, and spatial dispersion).

WFP/FAO/SE-CNSA/CSE/FEWS NET (2011). Comprehensive Food Security and Vulnerability Analysis (CFSVA). *Livelihood Zone Descriptions.*

Wiggins, S. (1995). Change in African farming systems between the mid-1970s and the mid-1980s. *Journal of International Development, 7(6),* 807-848.

Conventional wisdom holds that Africa has been undergoing an agrarian crisis marked by falling food production per capita and rising imports of cereals, as seen in national statistics. This paper tries to test whether African farmers have indeed experienced the suggested setbacks by looking at village-level studies of change in fanning systems between the mid-1970s and the mid-1980s. Fourteen studies from six countries were examined. Contrary to the above thesis, there was little evidence of decline and of much of the increased production per head, albeit by modest margins. If the studies are representative, then talk of crisis is exaggerated, the national statistics probably seriously underestimate farm output, and modest policy changes may suffice to support African farmers to produce and market more.

Wiggins, S. (2000). Interpreting changes from the 1970s to the 1990s in African agriculture through village studies. *World Development, 28(4),* 631-662.

Assessments of the performance of agriculture in sub-Saharan Africa are typically based on official production statistics at the national level. Between the early 1970s and the mid-1990s, these assessments often show alarmingly poor rates of growth, but there are good reasons to doubt the statistics and their interpretation. An alternative is to examine the record from the village level upward. This paper looks at the evidence from 26 case studies of change between the mid-1970s and the mid-1980s at the district or village level. These studies suggest less cause for alarm than the national statistics. They confirm that access to markets is essential for agricultural development — the single biggest idea in the policy reforms of the 1980s — in remedying failures in product, capital, and insurance markets, and in public investment in technology.

World Food Programme (2011). The Gambia - Comprehensive Food Security and Vulnerability Analysis. Available at: http://www.wfp.org/content/gambia-comprehensive-food-security-and-vulnerability-analysis-2011

Zorom, M., Barbier, B., et al. (2013). Diversification and adaptation strategies to climate variability: A farm typology for the Sahel. *Agricultural Systems, 116(0),* 7-15.

Sahelian farmers tend to diversify their activities to reduce their vulnerability to external shocks. It is important to distinguish between different ways farmers respond to these shocks as well as to policy incentives. To develop a typology of farmer adaptation strategies, to evaluate the level of vulnerability, and to assess perceptions of policies, two detailed questionnaire surveys were conducted in a community in northern Burkina Faso. Statistical analysis included a cluster analysis to distinguish farmers' types with regard to their assets and strategies. The results show that the main factors of discrimination were family size, access to small irrigation plots, and number of animals. The types react differently to climate variability and are likely to follow contrasting pathways of adaptation. Farmers' food vulnerability is still high according to the applied CILSS vulnerability index, and farmers are pessimistic about their capacity to handle future droughts. They see improved credit schemes and further development of irrigation as the most promising adaptation strategies.

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES Q – T

SEPTEMBER 2014

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African and Latin American
Resilience to Climate Change Project

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ANNEX Q. MODELISATION DES RENDEMENTS AGRICOLES DANS LE NORD-EST DU SENEGAL

REPUBLIQUE DU SENEGAL
MINISTERE DE L'AGRICULTURE

Institut Sénégalais
de Recherches Agricoles
Centre National de Recherches Agronomiques

Modélisation des rendements agricoles dans le nord-est du Sénégal

Dr Mbaye DIOP

ISRA, Décembre 2013

SUMMARY

The study of the impact of climate change on agriculture is conducted on millet, groundnut, sorghum, corn and cowpea crops in north-east Senegal (Matam, Kanel, Bakel and Goudiry departments).

The model approach is applied to the historical periods (1971-2010), by considering dry, normal and rainy years, as well as the future with predictions of climate change scenarios in 2030 and 2050 with dry, normal and surplus scenarios. The main objective of the model project is to evaluate the level of yield for each crop in function of the climatic and pedological conditions and the characteristics of the crop considered.

The results show that for the millet crops, the yield is overall low, because deficits are seen everywhere in comparison to the 1995/1998 reference, with peaks that can reach -19% in the extreme north of Senegal. By contrast, for the other crops, the yield is overall good, with surplusses that can exceed 100%.

Considering the scenarios of climate change, the results show a drop of potential yields in dry scenarios and surplus in humid scenarios. This is the case for sorghum in 2030, with an increase of 34%.

RESUME

L'étude de l'impact du changement climatique sur l'agriculture est conduite sur les cultures de mil, d'arachide, de sorgho, de maïs et de niébé dans le nord-Est du Sénégal (départements de Matam, Kanel, Bakel et Goudiry).

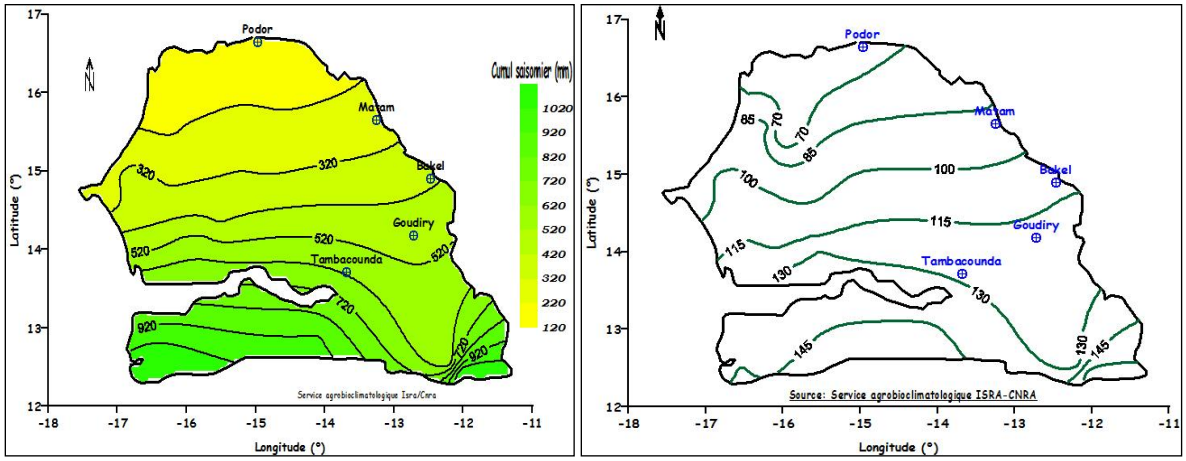
L'approche par modélisation est appliquée aussi bien sur la période historique (1971-2010), en considérant des années types sèches, normales et pluvieuses, que sur le futur avec des prévisions de scénarii de changement climatique en 2030 et 2050, avec des scénarii sec, normal et excédentaire. L'objectif principal du travail de modélisation est d'évaluer le niveau de rendement pour chaque culture, en fonction des conditions climatiques, pédologiques et des caractéristiques de la culture considérée.

Les résultats montrent que pour la culture du mil, les rendements sont globalement faibles car des déficits sont observés partout en comparaison à référence 1995/1998, avec des pics pouvant atteindre -19% dans l'extrême nord du Sénégal. En revanche, pour les autres cultures, les rendements sont globalement bons, avec des excédents pouvant dépasser 100%.

Considérant les scénarii de changement climatique, les résultats montrent une baisse des rendements potentiels en scénario sec et des excédents en scénario humide. C'est le cas pour le sorgho en 2030, avec une hausse de 34%.

INTRODUCTION

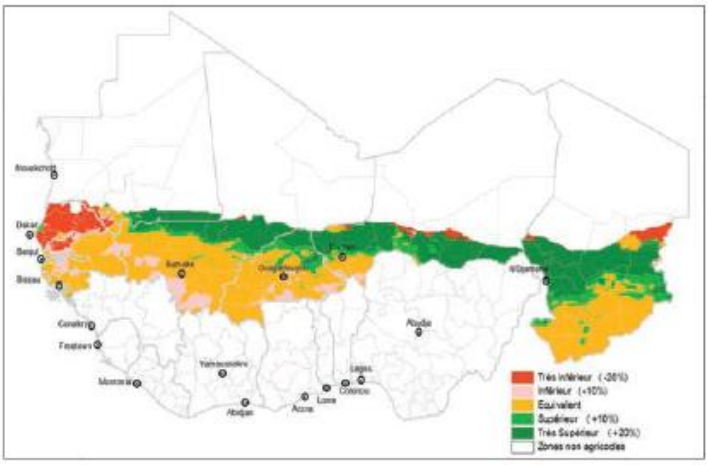
L'agriculture sénégalaise est très sensible aux conditions climatiques, car 96% des plantes cultivées sont pluviales et se pratiquent sur 3 à 4 mois (Figure 1). Or, dans l'annexe sur le climat il a été montré, que le Sénégal dans son ensemble est sujet à une variabilité interannuelle et intra-annuelle de la pluviométrie, et rend vulnérable le secteur agricole.



Figures 1. Variabilité spatiale du cumul saisonnier et de la longueur de la saison humide au Sénégal (1971-2010).(Sarr, 2013)

Plusieurs travaux ont utilisé l'approche de la modélisation pour analyser l'impact du climat sur les cultures, et prévoir les rendements. Le Centre Régional AGRHYMET, basé à Niamey utilise de manière opérationnelle le modèle DHC-CP (Diagnostic Hydrique des Cultures – Champs Pluviaux) pour faire des prévisions des rendements de céréales en Afrique occidentale sahélienne (figure 2).

Figure 2 : Prévisions des rendements de céréales au CILSS effectuées en août 2013 (source : Agrhymet, 2013)



Cependant, compte tenu la nécessité d'améliorer les outils de prévisions des rendements, la recherche a continué à travailler sur les modèles existants et sur de nouveaux outils (ARABHY, SARRAH, DSSAT, CROPWAT, etc.).

Dans le cadre de cette étude, nous utiliserons le modèle CROPWAT, développé par la FAO qui a l'avantage d'être relativement simple, donc ne nécessite pas de très nombreuses données en entrée, mais prend en compte le principal facteur limitant pour les cultures : la disponibilité de l'eau. En outre il a été développé pour de nombreuses cultures, ce qui n'est pas le cas des autres modèles agronomiques. Il produit comme résultat le rendement potentiel, c'est-à-dire le niveau de production pouvant être atteint à l'hectare, en l'absence de contraintes (eau, parasites, maladies, fertilité) et en suivant respectant les ititéraires techniques de production. Le modèle est appliqué dans ce travail aux principales cultures rencontre dans la zone d'étude, à savoir : le mil, le sorgho, le maïs, l'arachide et le niébé (haricot local).

L'approche adoptée dans cette étude pour estimer l'impact des conditions climatiques sur les rendements potentiels consiste en deux étapes :

1. évaluation de l'impact de la variabilité pluviométrique actuelle en simulant les rendements potentiels en année normale, humide et sèche. Cette étape a pour but d'évaluer la sensibilité des différentes cultures aux variations actuelles et construire une référence pour les impacts des conditions climatiques futures.
2. Evaluation de l'impact des conditions climatiques projetées pour 2030 et 2050 par 3 modèles parmi tous les modèles climatiques pris en compte dans l'étude: le premier projetant un climat sec dans la région, le deuxième un climat humide et le troisième proche de la moyenne de tous les modèles.

Le rapport s'articule autour des sections suivantes :

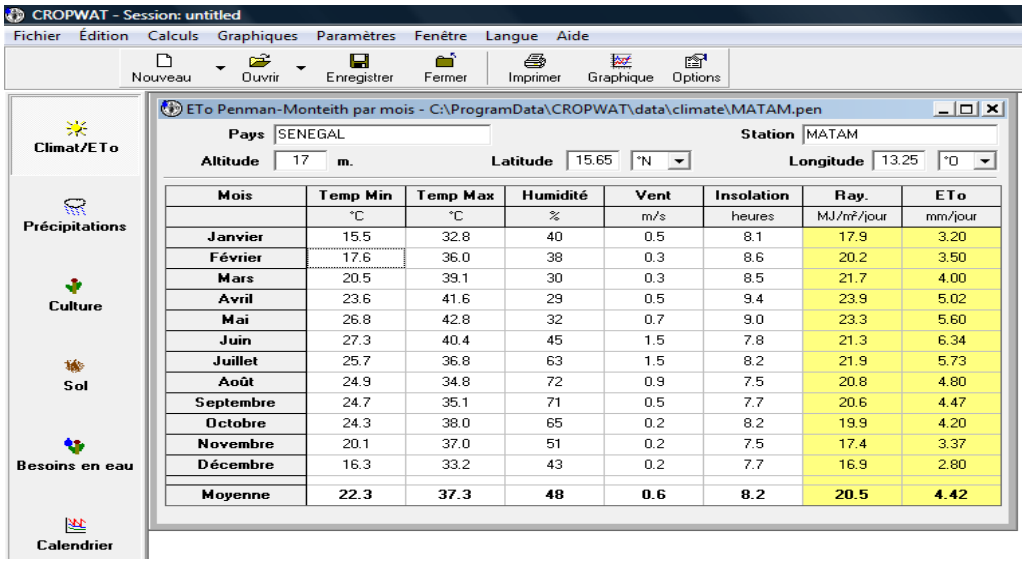
- Présentation du modèle et des données utilisées
- Présentation des rendements potentiels sous conditions climatiques actuelles
- Présentation des rendements potentiels sous conditions climatiques projetées pour le futur
- Discussion et conclusions

DÉMARCHE MÉTHODOLOGIQUE

Le modèle CROPWAT

Le modèle est basé sur l'évaluation du bilan hydrique des cultures et le calcul des indicateurs de rendement. Il utilise la formule de Penman-Monteith pour calculer l'évapotranspiration de référence (ETo) (http://www.fao.org/docrep/X0490E/x0490e00.htm#Contents Part A - Reference evapotranspiration (ET_o). Pour cela, différents paramètres climatiques sont considérés en entrée : les précipitations, la température, le rayonnement, la vitesse du vent et l'humidité relative de l'air. Les données pluviométriques sont également utilisées pour calculer les précipitations efficaces et évaluer le niveau de satisfaction des besoins en eau des cultures. Celui-ci est calculé en faisant le rapport entre la consommation réelle en eau simulée des cultures (ETc) et la consommation potentielle (ETm).

La figure 3 illustre l'utilisation de ces données dans le modèle CROPWAT.



Mois	Temp Min	Temp Max	Humidité	Vent	Insolation	Ray.	ETo
	°C	°C	%	m/s	heures	MJ/m²/jour	mm/jour
Janvier	15.5	32.8	40	0.5	8.1	17.9	3.20
Février	17.6	36.0	38	0.3	8.6	20.2	3.50
Mars	20.5	39.1	30	0.3	8.5	21.7	4.00
Avril	23.6	41.6	29	0.5	9.4	23.9	5.02
Mai	26.8	42.8	32	0.7	9.0	23.3	5.60
Juin	27.3	40.4	45	1.5	7.8	21.3	6.34
Juillet	25.7	36.8	63	1.5	8.2	21.9	5.73
Août	24.9	34.8	72	0.9	7.5	20.8	4.80
Septembre	24.7	35.1	71	0.5	7.7	20.6	4.47
Octobre	24.3	38.0	65	0.2	8.2	19.9	4.20
Novembre	20.1	37.0	51	0.2	7.5	17.4	3.37
Décembre	16.3	33.2	43	0.2	7.7	16.9	2.80
Moyenne	**22.3**	**37.3**	**48**	**0.6**	**8.2**	**20.5**	**4.42**

Figure 3 : Données climatiques mensuelles utilisées à l'entrée du modèle CROPWAT pour le calcul de l'ETo.

Outre les données climatiques, le modèle utilise également les données de sols. Il s'agit précisément de la texture (sableuse ou argileuse), de la réserve utile en eau, de la profondeur et de la teneur en eau du sol au moment du semis.

La FAO fournit une base de données sur les variétés des cultures permettant de renseigner le modèle. En l'absence de données d'observations locales, cette base de données est utilisée pour la modélisation des cultures (figure 4).

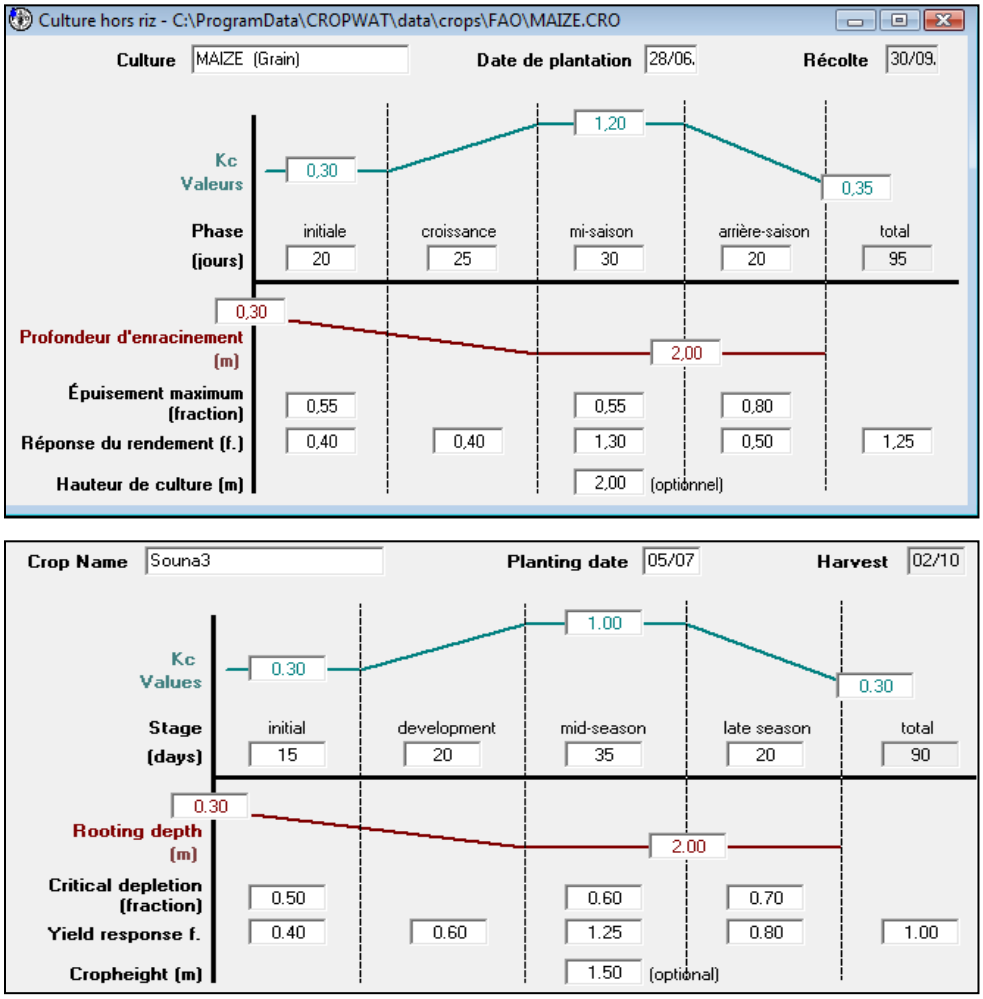


Figure 4 : Paramètres culturaux utilisés dans CROPWAT pour la simulation du bilan hydrique.

En plus des données climatiques et agronomiques, CROPWAT utilisé également les données sur les sols, à savoir le type de sol, sa profondeur et les caractéristiques hydriques (réserve utile en eau, humidité initiale).

L'ensemble de ces données permet de calculer le niveau de consommation d'eau qui est très lié à la productivité des cultures, surtout pluviales, en zone soudano-sahélienne. Une consommation d'eau faible se traduit par une baisse importante des rendements de la culture (Mémento de l'agronome, 2002). Le coefficient de baisse de rendement potentiel (Ky), calculé par le modèle CROPWAT, est obtenu en appliquant l'équation :

$$Ky=1 - ETc/ETm.$$

Il détermine le pourcentage de baisse du rendement potentiel et permet ainsi d'estimer le rendement potentiel obtenu.

Ainsi, nous avons pu calculer, pour chaque culture, le rendement potentiel obtenu selon les conditions climatiques de l'année considérée et le contexte pédologique, en utilisant l'équation :

$$Rdt_{pot_act} = Rdt_{pot} - (Rdt_{pot}*Ky).$$

où: Rdt_{pot_act} = rendement potentiel de l'année considérée

Rdt_{pot} = rendement potentiel de la culture

K_y = coefficient de baisse du rendement

Le rendement potentiel correspond au rendement que la culture aurait pu obtenir dans le contexte pédoclimatique considéré et en l'absence de facteur limitant. Il est toujours supérieur au rendement réel en milieu paysan, compte tenu des nombreuses contraintes biotiques et abiotiques qui caractérisent l'agriculture traditionnelle au Sénégal (pauvreté des sols, qualité des semences, ravageurs, etc.). Pour chaque variété considérée, la recherche a pu déterminer le rendement potentiel (tableau 2).

Tableau 2 : Rendements potentiels des variétés de cultures considérées (ISRA, 2012)

Cultures	Variétés	Rendements potentiels
Mil	Souna 3 / Thialack	2 500 kg/ha
Maïs	Hybride	2500 kg/ha
Sorgho	CE-180-33	3900 kg/ha
Arachide	73-33 / 55-437	2000 kg/ha
Niébé	Ndiambour	1300 kg/ha

Les prévisions de rendements concernent 5 cultures : mil, arachide, niébé, sorgho et maïs dans chacun des 4 départements de la zone d'étude, mais aussi à Podor et à Tamba. La simulation a été pour les années types présentées dans la section suivante tableau 1.

Données

Les données climatiques nécessaires au modèle CROPWAT sont disponibles au niveau de l 'ISRA pour 6 stations (Matam, Kanel, Bakel, Goudiry et Podor) sur la période1971-2010. Il s'agit de données mensuelles qui sont transformées en données journalières par le logiciel CROPWAT. Pour les départements où les données climatiques n'existent pas, celles des stations les plus proches sont considérées. Ainsi, pour certaines années, les données climatiques de Matam sont utilisées pour Kanel et Bakel et celles de Tamba pour Goudiry.

Pour évaluer la sensibilité des cultures à la variabilité climatique actuelle, les rendements ont été simulés pour une série d'années sélectionnées comme étant sèches, normales et humides sur l'ensemble des stations[1], identifiées par une analyse statistique. En outre pour documenter les changements climatiques intervenus pendant les années 70-80 (période généralement plus

[1] Parce que chaque année devait être déficitaire, excédentaire ou normale sur l'ensemble des stations, une année donnée n'est pas forcement la plus déficitaire ou la plus excédentaire dans chacune des stations prises individuellement.

sèche) et 90-2010 (période plus humide) ces sélections ont été opérées pour chaque période individuellement. Le tableau 3 présente la sélection des années.

Tableau 3 : Années sélectionnées pour la modélisation des cultures.

Années sèches	Années moyennes	Années humides
1984, 1977, 1992	**1987, 1979, 1995, 1998**	**1988, 1981, 1994**

Pour prendre en compte l'impact du changement climatique futur sur les rendements agricoles, on a considéré des projections des pluies et températures mensuelles sous le scenario RCP4.5 pour les horizons 2030 et en 2050 produites par un modèle parmi ceux qui simulent des conditions les plus sèches, un modèle parmi ceux qui simulent les conditions les plus humides et un proche de la moyenne de tous les modèles. Les données sur les conditions projetées pour le futur ont été fournies par ARCC et sont décrites plus en détail en annexe. Les rendements simulés sont comparés avec ceux obtenus pour la moyenne des années normales de la période 1991-2010 c'est-à-dire 1995 et 1998. Cette approche suppose le maintien des mêmes variétés sur le terrain et le maintien des mêmes pratiques culturales.

PRESENTATION DES RENDEMENTS POTENTIELS SOUS CONDITIONS CLIMATIQUES ACTUELLES

Rendements du mil

Les résultats montrent que pour l'ensemble des sites, le rendement potentiel moyen sur la période 1971-2010 est globalement faible par rapport à la référence 1995/1998. En effet, des déficits sont partout observés et peuvent atteindre 19%, notamment dans l'extrême nord du Sénégal, notamment à Podor (tableau 4).

Tableau 4 : Pourcentage de baisse du rendement potentiel moyen du mil pendant la période 1971-2010 par rapport à la référence 1995/1998

	Matam	Kanel	Bakel	Goudiry	Tamba	Podor
Par rapport à la référence 1995/1998	-6%	-8%	-4%	-5%	-1%	-19%

Ces résultats attestent de la sensibilité du modèle à la variabilité pluviométrique. Pour chaque année, les rendements potentiels simulés sont comparés avec le rendement normal de la période dans laquelle elle se trouve (1971-1990 ou 1991-2010). Les résultats montrent des déficits de rendement très importants pendant les années sèches (46% de baisse en 1984 à

Matam et 52% à Bakel). En revanche, les années humides sont caractérisées par des hausses de rendement et ces hausses sont plus importantes à Matam. (Tableau 5).

Tableau 5 : Rendements simulés du souna 3 dans le nord-est du Sénégal.

Culture : Mil		**Matam**		**Bakel**		**Goudiry**		**Tamba**		**Podor**	
Type d'année		Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
Année sèche	1977	1 060	-23%	662	-56%	1 314	-33%	1 962	5%	704	-56%
	1984	506	-63%	874	-41%	1 840	-6%	1 834	-2%	178	-89%
	1992	732	-47%	832	-44%	1 550	-21%	1 750	-6%	906	-44%
Année normale	1987	898	-35%	1 658	11%	1 960	0%	1 968	5%	828	-48%
	1979	1 768	28%	1 344	-10%	1 710	-13%	1 954	5%	1 116	-30%
	1995	1 290	-7%	1 798	21%	1 974	1%	1 926	3%	1 226	-24%
	1998	1 472	7%	1 186	-21%	1 946	-1%	1 808	-3%	1 990	24%
Année humide	1981	1 432	4%	1 862	25%	1 928	-2%	1 906	2%	1 846	15%
	1988	1 788	29%	1 798	21%	1 926	-2%	1 942	4%	1 592	-1%
	1994	1 410	2%	1 634	10%	1 634	-17%	1 808	-3%	500	-69%

Rendements du maïs

L'analyse du tableau 6 montre qu'en moyenne, le rendement potentiel du maïs est excédentaire en comparaison avec la référence (moyenne des années 1995 et 1998).

Tableau 6 : Comparaison du rendement potentiel moyen de maïs de la période 1971-2010 par rapport à la référence 1995/1998

	Matam	Kanel	Bakel	Goudiry	Tamba	Podor
Par rapport à la référence 1995/1998	93%	109%	77%	90%	97%	71%

Cependant des baisses sont observées surtout en année sèche. Le tableau 6 illustre l'importance des baisses de rendement potentiel en année sèche dans la partie nord, notamment à Matam où elle a atteint 90% par rapport à la moyenne 1995/1998 et 100% à Podor.

En année normale les baisses les plus importantes sont également dans dans ces deux sites, alors que le sud présente des rendements normaux.

En année humide, ce sont dans les mêmes sites les hausses de rendements potentiels sont les plus élevées 53% à Matam en 1981 et 44% à Podor la même année (Tableau 7).

Tableau 7 : Rendements simulés du maïs dans le nord-est du Sénégal.

Culture : Maïs		**Matam**		**Kanel**		**Bakel**		**Goudiry**		**Tamba**		**Podor**	
Type d'année		Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
Année sèche	1977	1193	-34%	1197	- 0,22	2215	-39%	2421	-35%	2 225	-5%	310	-69%
	1984	187	-90%	202	- 0,87	772	-79%	3209	-13%	1 945	-17%	-	-100%
	1992	405	-78%	1107	- 0,28	2375	-35%	2983	-20%	1 973	-16%	535	-47%
Année normale	1987	1415	-22%	1271	- 0,17	2191	-40%	3708	0%	2 465	5%	473	-53%
	1979	2421	33%	2418	0,57	3276	-10%	3123	-16%	2 428	3%	878	-13%
	1995	1618	-11%	2046	0,33	3783	4%	3599	-3%	2 425	3%	1 018	1%
	1998	2012	11%	1033	- 0,33	3494	-4%	3814	3%	2 268	-3%	1 005	-1%
Année humide	1981	2780	53%	2386,8	0,55	2952	-19%	3829	3%	2 385	2%	1 458	44%
	1988	2414	33%	2425	0,58	3038	-17%	3728	1%	2 433	4%	1 458	44%
	1994	2410	33%	2636	0,71	3884	7%	3057	-18%	2 285	-3%	48	-95%

Rendements de l'arachide

Le rendement potentiel moyen de l'arachide sur la période 1971-2010 est excédentaire, comparativement à la référence 1995-1998 (tableau 8).

Tableau 8 : Comparaison du rendement potentiel moyen de l'arachide de la période 1971-2010 par rapport à la référence 1995/1998

	Matam	Kanel	Bakel	Goudiry	Tamba	Podor
Par rapport à la référence 1995/1998	96%	100%	84%	97%	98%	91%

Cependant, selon la configuration climatique des années, des nuances sont observées. En effet, une baisse généralisée des rendements potentiels est notée dans toute la zone d'étude en année sèche (tableau 9). En année moyenne, les rendements continuent de baisser à Matam, Bakel et Podor et restent proches de la normale à Goudiry et Tamba. En année humide on observe des rendements proches de la normale. Des baisses sont toutefois observées à Bakel et à Podor et la plus importante hausse est enregistrée à Matam en 1981 avec 18%.

Tableau 9 : Rendements simulés de l'arachide dans le nord-est du Sénégal.

Culture : Arachide		**Matam**		**Bakel**		**Goudiry**		**Tamba**		**Podor**	
Type d'année		Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
Année sèche	1977	1 513	-13%	1 843	-25%	1 653	-28%	2 188	-8%	938	-26%
	1984	1 135	-35%	1 318	-46%	2 093	-9%	2 180	-8%	860	-32%
	1992	1 235	-29%	1 878	-24%	2 243	-3%	2 228	-6%	1 095	-13%
Année normale	1987	1 403	-20%	1 783	-28%	2 408	5%	2 430	2%	1 188	-6%
	1979	1 963	12%	2 205	-10%	2 270	-1%	2 433	2%	1 098	-13%
	1995	1 678	-4%	2 418	-2%	2 293	0%	2 415	2%	1 400	11%
	1998	1 818	4%	2 500	2%	2 313	0%	2 338	-2%	1 130	-11%
Année humide	1981	2 070	18%	2 223	-10%	2 465	7%	2 463	4%	1 455	15%
	1988	1 940	11%	2 098	-15%	2 425	5%	2 223	-6%	1 248	-1%
	1994	1 948	11%	2 475	1%	2 250	-2%	2 373	0%	1 055	-17%

Rendements du niébé

Pour la culture de niébé (haricot local), le rendement potentiel moyen obtenu sur la période d'étude (1971-2010), est largement excédentaire comparativement à la référence 1995-1998 (tableau 10).

Tableau 10 : Comparaison du rendement potentiel moyen du niébé de la période 1971-2010 par rapport à la référence 1995/1998

	Matam	Kanel	Bakel	Goudiry	Tamba	Podor
Par rapport à la référence 1995/1998	90%	101%	85%	92%	102%	84%

Comme pour les autres cultures, les rendements potentiels sont meilleurs au sud, surtout pendant les années sèches (tableau 11). Aussi, la baisse par rapport à une année normale est plus forte au nord, avec par exemple 50% et de baisse à Matam en 1984 contre seulement 15% à Goudiry.

Tableau 11 : Rendements potentiels simulés du niébé dans le nord-est du Sénégal.

Culture : Niebe		**Matam**		**Kanel**		**Bakel**		**Goudiry**		**Tamba**		**Podor**	
Type d'année		Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %
Année sèche	1977	831	-22%	836	-12%	1 047	-27%	944	-32%	1 460	9%	627	-34%
	1984	527	-50%	506	-47%	660	-54%	1 454	4%	1 365	2%	321	-66%
	1992	612	-42%	819	-13%	1 056	-26%	1 157	-17%	1 130	-16%	752	-21%
Année normale	1987	744	-30%	842	-11%	1 074	-25%	1 347	-3%	1 470	10%	696	-27%
	1979	1 190	12%	1 106	17%	1 337	-6%	1 185	-15%	1 463	9%	881	-7%
	1995	1 028	-3%	1 094	16%	1 424	0%	1 361	-3%	1 382	3%	951	0%
	1998	1 094	3%	800	-16%	1 434	0%	1 431	3%	1 296	-3%	950	0%
Année humide	1981	1 265	19%	1 187	25%	1 428	0%	1 472	5%	1 421	6%	1 142	20%
	1988	1 116	5%	1 134	20%	1 182	-17%	1 409	1%	1 449	8%	1 136	19%
	1994	1 172	10%	1 245	32%	1 478	3%	1 149	-18%	1 274	-5%	504	-47%

Rendement de sorgho

Comme pour les autres cultures, le rendement potentiel est largement supérieur à la moyenne de 1995/1998, avec des pourcentages de hausse partout supérieurs à 80% (tableau 12).

Tableau 12 : Comparaison du rendement potentiel moyen du sorgho de la période 197162010 par rapport à la référence 1995/1998.

	Matam	Kanel	Bakel	Goudiry	Tamba	Podor
Par rapport à la référence 1995/1998	93%	104%	86%	92%	99%	83%

Mais à Goudiry aussi, le niveau de rendement diffère selon le type d'année. Pendant les années sèches et moyennes, les rendements sont pratiquement toujours inférieurs à la moyenne de 1995/1998 considérée comme référence.

En année humide, le rendement est soit en hausse ou en baisse selon l'année ou la station (tableau 13).

Tableau 13 : Rendements simulés du sorgho dans le nord-est du Sénégal

Culture : Sorgho		Matam		Bakel		Goudiry		Tamba		Podor	
Type d'année		Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %	Rdt pot	Δ rdt %
Année sèche	1977	1400	-19%	2 917	-23%	2 551	-34%	3 795	3%	1 595	-36%
	1984	840	-52%	1 739	-54%	3 767	-2%	3 533	-5%	714	-71%
	1992	982,5	-43%	2 909	-24%	3 299	-14%	3 218	-13%	1 892	-24%
Année normale	1987	1237,5	-29%	3 038	-20%	3 744	-3%	3 857	4%	1 802	-27%
	1979	2050	18%	3 693	-3%	3 354	-13%	3 826	3%	2 297	-7%
	1995	1640	-6%	3 810	0,1%	3 861	0%	3 806	3%	2 488	0,4%
	1998	1832,5	6%	3 803	-0,1%	3 830	0%	3 596	-3%	2 469	-0,4%
Année humide	1981	2215	28%	3 541	-7%	3 842	0%	3 752	1%	3 058	23%
	1988	1925	11%	3 288	-14%	3 764	-2%	3 818	3%	3 081	24%
	1994	2047	18%	3 892	2%	3 284	-15%	3 611	-2%	1 256	-49%

1. PRÉSENTATION DES RENDEMENTS POTENTIELS SOUS CONDITIONS CLIMATIQUES PROJETÉES POUR LE FUTUR

Pour évaluer l'impact du changement climatique sur les rendements des cultures, nous avons utilisé les données climatiques des projections à 2030 et à 2050. Pour chaque horizon, le rendement est simulé pour un scénario sec, normal et humide.

Les rendements obtenus sont comparés avec le rendement moyen des années 1995 et 1998.

Les rendements de mil

Pour le scénario 2030, les résultats montrent que :

- pour le scénario sec, on constate une baisse généralisée du rendement potentiel (tableau 14).
- pour le scénario normal, les seules baisses sont observées au nord avec -20% à Matam et -52% à Podor.
- le scénario humide, seul Tamba affiche une situation déficitaire dont une cause pourrait être une mauvaise répartition des pluies durant le cycle végétatif où un excès d'eau en cas de semis précoce.

Tableau 14 : Comparaison des scénarii de rendement de mil en 2030 avec la moyenne 1995-1998.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2030	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1 194	-14%	962	-36%	1 712	-13%	1 406	-25%	68	-96%
scénario normal	1 098	-20%	1 946	30%	1 976	1%	1 868	0%	770	-52%
scénario humide	1 432	4%	2 000	34%	1 932	-1%	1 362	-27%	1 520	-5%

A l'horizon 2050, les résultats montrent :

- pour le scénario sec, une baisse est observée partout, mais elle est plus accentuée dans l'extrême nord, avec -72% à Podor (tableau 15).
- pour le scénario normal, une très légère hausse est observée dans la partie sud (7% à Tamba, 2% à Goudiry). Ailleurs, la tendance est plutôt à la baisse (-13% à Matam, -24% à Bakel et -30% à Podor).
- pour le scénario humide, une importante hausse est notée à Bakel (34%). Seul Podor affiche une baisse de 40%.

Tableau 15 : Comparaison des scénarii de rendement de mil en 2050 avec la moyenne 1995-1998.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2050	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %
scénario sec	1 288	-7%	1 272	-15%	1 936	-1%	1 758	-6%	458	-72%
scénario normal	1 206	-13%	1 134	-24%	1 996	2%	1 998	7%	1 118	-30%
scénario humide	1 538	11%	2 000	34%	1 946	-1%	1 946	4%	962	-40%

Les rendements de maïs

Pour le scénario 2030, les résultats montrent :

- pour le scénario sec, une baisse importante partout atteignant même 100% à Podor (tableau 16). Seul Tamba affiche un minimum de baisse.
- pour le scénario normal, une réduction du rendement potentiel est observée partout sauf à Tamba où il est resté stable.
- pour le scénario humide, une hausse 35% à Podor, où avec la faiblesse du rendement potentiel moyen, la hausse pluviométrique du scénario humide entraîne un rendement élevé. Ailleurs, une baisse est observée.

Tableau 16 : Comparaison des scénarii de rendement de maïs en 2030 avec la moyenne 1995/1998

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2030	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	948	-48%	2 110	-42%	1 533	-59%	2 168	-8%	-	-100%
scénario normal	815	-55%	1 993	-45%	2 320	-37%	2 388	2%	408	-60%
scénario humide	1 695	-7%	2 390	-34%	2 135	-42%	1 618	-31%	1 365	35%

Considérant l'horizon 2050, on observe une baisse du rendement potentiel partout, quel que soit le scénario considéré (tableau 17). C'est seulement à Tamba qu'on enregistre une faible hausse de rendement en année normale et humide.

Tableau 17 : Comparaison des scénarii de rendement de maïs en 2050 avec la moyenne 1995/1998

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2050	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1 088	-40%	1 183	-68%	1 918	-48%	2 313	-1%	18	-98%
scénario normal	963	-47%	840	-77%	2 380	-36%	2 465	5%	860	-15%
scénario humide	1 438	-21%	2 500	-31%	2 295	-38%	2 448	4%	695	-31%

Les rendements d'arachide

En 2030, les rendements d'arachide des scénarii sec et normal connaîtront une baisse plus importante à Bakel et à Tamba et faible dans les autres sites (tableau 18).

Pour le scénario humide, il n'y a pas d'évolution notoire des rendements, sauf à Podor où on observe une hausse de 34%.

Tableau 18 : Comparaison des scénarii de rendement d'arachide en 2030 avec la moyenne de 1995/1998

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2030	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %	Rdt pot	Δ %
scénario sec	1625	-7%	1560	-37%	2077	-10%	1870	-21%	1465	16%
scénario normal	1540	-12%	2147	-13%	2292	0%	2020	-15%	1447	14%
scénario humide	1810	4%	2315	-6%	2380	3%	2360	-1%	1700	34%

En 2050, des baisses très peu significatives des rendements sont observées pour le scénario sec et normal à Matam, Tamba et Goudiry, contrairement à Bakel où on a une baisse de 31 à 36% (tableau 19). Pour le scénario humide, une légère hausse du rendement est observée à Matam

et la hausse est assez forte à Podor. Ailleurs, il n'y a pas de changement par rapport à la référence 1995-1998. Dans les autres sites, il n'y a pas de changement significatif du niveau de rendement potentiel, par rapport à la référence 1995-1998.

Tableau 19 : Comparaison des scénarii de rendement d'arachide en 2050 avec la moyenne 1995-1998.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2050	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1697	-3%	1562	-36%	2067	-10%	2370	0%	1322	5%
scénario normal	1652	-5%	1695	-31%	2080	-10%	2445	3%	1712	35%
scénario humide	1962	12%	2442	-1%	2282	-1%	2490	5%	1742	38%

Les rendements de niébé

Une légère baisse des rendements de niébé est attendue en 2030 à Matam en cas d'année sèche (4%) ou normale (10%), contre une hausse de 24% en cas d'année humide (tableau 20).

A Bakel, une forte baisse de 37% est observée en cas d'année sèche en 2030, alors qu'une hausse de 16% est attendue en cas d'année normale et de 19% en cas d'année humide.

Les rendements seront réduits en 2030 à Goudiry de 23% en cas d'année sèche et de 6% seulement si 2030 est humide. En année normale, les rendements augmenteront seulement de 6%.

Tableau 20 : Comparaison des scénarii de rendement de niébé en 2030 avec la moyenne 1995/1998.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2030	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1220	-14%	1036	-46%	1322	-29%	400	-24%	1010	-18%
scénario normal	1140	-19%	1898	0%	1624	-13%	448	-15%	1054	-15%
scénario humide	1440	2%	1940	2%	1824	-2%	730	38%	1928	56%

En 2050, l'évolution la plus significative à Matam est observée en cas d'année humide avec une hausse de 24% (tableau 21).

A Bakel, les rendements vont être réduits de 22% en cas d'année sèche ou humide et augmenteront de 21% en cas d'année humide.

A Goudiry, les rendements ne connaîtront pas de changement important, quel que soit le scénario pluviométrique.

Tableau 21 : Comparaison des scénarii de rendement de niébé en 2050 avec la moyenne 1971-2010.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2050	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1228	-13%	1154	-39%	1598	-14%	646	22%	1024	-17%
scénario normal	1358	-4%	1272	-33%	1804	-3%	746	41%	1208	-2%
scénario humide	1464	4%	2000	5%	1732	-7%	970	83%	1490	21%

1.1. *LES RENDEMENTS DE SORGHO*

Pour le scénario 2030, les résultats montrent que :

- pour le scénario sec, les rendements de sorgho sont partout à la baisse par rapport à la moyenne 1995/1998. En revanche, il y aura une baisse de 20% et 30%, respectivement à Bakel et Goudiry (tableau 22).
- pour le scénario normal, il n'y a pas de grande différence par rapport à la période 1995/1998 à Goudiry et Tamba. Par contre, une hausse de 30% est observée à Bakel, tandis que le rendement est stable à Goudiry et à Tamba..

Tableau 22 : Comparaison des scénarii de rendement de sorgho en 2030 avec la moyenne 1995/1998.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2030	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1 194	-14%	962	-36%	1 712	-13%	1 406	-25%	68	-96%
scénario normal	1 098	-20%	1 946	30%	1 976	1%	1 868	0%	770	-52%
scénario humide	1 432	4%	2 000	34%	1 932	-1%	1 362	-27%	1 520	-5%

L'analyse du tableau 23 montre qu'en 2050, il n'y aura pas de changement significatif du rendement potentiel à Tamba et à Goudiry, par rapport à la référence (1995/1998).

Une hausse de 34% est attendue à Bakel contre une baisse de 41% à Podor en cas d'année humide en 2050

Tableau 23 : Comparaison des scénarii de rendement de sorgho en 2050 avec la moyenne 1971-2010.

	Matam		Bakel		Goudiry		Tamba		Podor	
scénario CC 2050	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %	Rdt pot	variation %
scénario sec	1 288	-7%	1 272	-15%	1 936	-1%	1 758	-6%	458	-72%
scénario normal	1 206	-13%	1 134	-24%	1 996	2%	1 998	7%	1 118	-30%
scénario humide	1 538	11%	2 000	34%	1 946	-1%	1 946	4%	962	-40%

CONCLUSION ET DISCUSSIONS

La modélisation des rendements des cultures les plus pratiquées dans le Nord-Est du Sénégal a été réalisée en utilisant CROPWAT, un logiciel de bilan hydrique développé par la FAO. Elle a porté à la fois sur la période historique, en ciblant des années types (sèches, normales et humides) et sur des projections futures (2030 et 2050) avec des scénarii d'années sèche, normale et déficitaires.

Sur la période historique, on note une baisse du rendement potentiel des différentes cultures pendant les années sèches et une hausse pendant les années normales et humides.

En considérant les scénarii de changement climatique, une baisse des rendements potentiels est globalement attendue en scénario sec et globalement excédentaire en scénario humide. Toutefois des incohérences sont parfois observées, à savoir une hausse de rendement en scénario sec ou une baisse en scénario humide.

La répartition de la pluviométrie durant le cycle de croissance des cultures peut être une cause pouvant expliquer ces incohérences.

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ANNEX R. ÉVALUATION DE LA VULNÉRABILITÉ DU SÉNÉGAL AU CHANGEMENT CLIMATIQUE ET ANALYSE DES OPTIONS

BUREAU D'ANALYSES MACRO-ECONOMIQUES

ETUDE ARCC

Évaluation de la vulnérabilité du Sénégal au changement climatique et analyse des options

RAPPORT INSTITUTIONS

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SUMMARY

As part of the Senegal Climate Change Vulnerability Study and Options Analysis, interviews were conducted with state technical services, leaders of rural communities, project and development programs, and merchants in the Matam, Kanel, Bakel and Goudiry regions of Senegal. The purpose of the interviews was to analyze a number of parameters that directly relate to climate change and food security. The different parameters include 1) the current ability of key actors to provide information, resources, and training at the local level; 2) their awareness of and responses to climate variability and extremes; 3) their level of awareness and understanding of climate change; 4) programs and actions being undertaken in relation to climate change; and 5) the ability of key actors to anticipate and plan, taking climate trends and risks into account, in order to address future needs.

The interviews revealed that there are many actors intervening in the region under study, but that their ability to provide information is limited by a lack of specific policies and financial resources. The skills that specifically pertain to organizing activities and raising awareness about climate change are not well developed in most local communities. Therefore, the actions that have been taken in response to climate change are very limited, considering the scope of the phenomenon.

The projects and NGOs in the study region pool their resources (financial and human) and provide support to decentralized structures and development enterprises, but their actions are isolated in time and space. Nevertheless, these key actors had a concrete awareness of the reality of climate change and its effects on agriculture, animal husbandry, and food security. The majority of the staff interviewed are aware of alterations due to climate change that have occurred over time and in a given territory. However, they show considerable hesitation regarding the actions that must be taken. We found that very few large-scale, endogenous initiatives have been initiated within either local populations or technical and development structures. NAPA and UNFCCC programs are well known within most projects and NGOs, but not among populations. Local communities have a very limited ability to anticipate and plan for future needs due to a lack of financial resources, local policies, and specific skills in this domain.

RÉSUMÉ

Dans le cadre de l'Évaluation de la vulnérabilité du Sénégal au changement climatique et l'analyse des options, des entretiens ont été menés auprès de services techniques de l'Etat, de présidents de communauté rurale, de projets et programmes de développement et de commerçants dans les zones de Matam, Kanel, Bakel, et Goudiry. Les entretiens avaient pour objectif d'analyser un certain nombre de paramètres qui entrent en ligne directe avec le changement climatique et la sécurité alimentaire. Ces différents paramètres sont : (1) la capacité réelle de ces principaux acteurs à fournir des informations, des ressources et une formation au niveau local, (2) la prise de conscience et les réponses par rapport aux tendances et aux chocs climatiques, (3) le degré de prise de conscience et de compréhension du changement climatique, (4) les programmes et actions en cours et en rapport au changement climatique et (5) les capacités d'anticipation et de planification des principaux acteurs, en tenant compte des tendances et risques climatiques pour faire face aux besoins futurs.

Les entretiens ont montré qu'il existe une multitude d'acteurs qui interviennent dans la zone de l'étude mais leur capacité à fournir des informations est limitée par l'absence de politiques spécifiques et de ressources financières. Les compétences spécifiques en matière d'animation et de sensibilisation sur les effets du changement climatique ne sont réunies chez la plupart des collectivités locales. Les actions entreprises en réponse au changement climatique sont très limitées quant à l'ampleur du phénomène.

Les projets et ONG présents dans la zone de l'étude mutualisent leurs moyens (financiers et humains) et viennent en appui aux structures décentralisées et sociétés de développement, mais leurs actions sont localisées dans l'espace et dans le temps. Cependant, on note une réelle prise de conscience des acteurs sur la réalité du changement climatique et de ses effets sur l'agriculture, l'élevage et la sécurité alimentaire. La plupart des acteurs interviewés sont conscients des modifications dues au changement climatique qui se sont opérées dans le temps et dans l'espace. Cependant, ils sont relativement attentistes quant aux actions à mener. Très peu d'initiatives endogènes de grandes envergures sont observées aussi bien chez les populations locales que les structures techniques et de développement. Les programmes du PANA et du CCNUCC sont bien connus par la plupart des projets et ONG, mais sont très peu connus des populations. Au niveau des collectivités locales, la capacité d'anticipation et de planification en rapport aux besoins futurs est très limitée du fait du manque de compétences spécifiques dans ce domaine, de politiques locales et de ressources financières.

INTRODUCTION

Dans le cadre de l'Évaluation de la vulnérabilité du Sénégal au changement climatique et l'analyse des options, des entretiens ont été menés auprès de services techniques de l'Etat, de dirigeants de communautés, de projets et programmes de développement et de commerçants dans la zone d'étude :

Matam, Kanel, Bakel, et Goudiry. Ainsi, une quarantaine d'interviews a été réalisée avec les acteurs institutionnels de ces départements : 13 dans le département de Matam, 08 dans le département de Kanel, 09 dans le département de Bakel et 10 dans le département de Goudiry (cf. Tableau récapitulatif en annexe). Les entretiens ont été menés par une équipe de deux économistes sur la période allant du 12 Novembre au 06 décembre 2013.

Dans le département de Matam, les entretiens ont été faits auprès de trois services techniques (le CADL, la Direction de l'élevage et le DRDR), quatres communautés rurales (Ogo, Bokidiawé, Nabadji Civol et Oréfondé, quatre commerçants (louma Nabadji Civol et Loumo Thilogne), l'USAID/Yaajeendé et la SAED.

Dans le département de Kanel, ils ont été faits auprès de deux services techniques (le service de l'élevage, le service de l'agriculture), trois communautés rurales (Ouro Sidi, Aouré et Bokeladji), un organisme privé qui s'est lancé dans le financement du maraîchage à travers la construction de forages et de ferme maraichers et deux commerçants (Orkadiéré).

Dans le département de Bakel, nos entretiens ont porté sur les communautés rurales de Gabou et de Sinthiou Fissa. Les services techniques de l'élevage et de l'agriculture, deux projets GRDR et ENDA-LEAD et des commerçants ont été interviewés.

Dans le département de Goudiry, nos entretiens ont été menés auprès de cinq communautés rurales (Koar, Dougué, Komoti, Bouynguel Bamba et de Sinthiou Mamadou Boubou). Mais également dans le louma de Balla. Les projets interviewés dans ce département sont le PAPIL et le PROGEDE. Seul le service de l'agriculture a été interviewé et le service des eaux et forêts et de l'élevage n'étaient pas disponibles.

L'objectif de ces entretiens était de collecter des informations sur la capacité des institutions à répondre et à appuyer leurs administrés sur les impacts du changement climatique. De plus, les actions et programmes pour une meilleure prise en compte des chocs climatiques ont été discutés avec les acteurs identifiés (services techniques, communautés rurales, projets ou ONG et commerçants), ainsi que leurs capacités d'anticipation et de planification en rapport aux tendances et risques climatiques et aux besoins futurs.

Ce rapport fait l'économie des entretiens réalisés avec ces différents acteurs en mettant l'accent sur les perceptions, l'orientation et les limites des institutions, sur l'évolution de la compréhension actuelle et passée du changement climatique.

I. CAPACITÉ RÉELLE À FOURNIR DES INFORMATIONS, DES RESSOURCES ET DE LA FORMATION AU NIVEAU LOCAL

Différentes structures et personnes ressources ont été rencontrées dans la zone d'étude. Il s'agit des services décentralisés de l'administration, des sociétés de développement, les projets et ONG ainsi que des commerçants locaux (dans les louma).

Leur mission est de favoriser un développement économique et social au niveau local tout en se référant aux grandes lignes politiques identifiées au niveau national. Cependant, c'est dans la mise en œuvre des activités que nous pouvons observer des différences qui peuvent s'expliquer par les spécialisations et les orientations des acteurs.

Au niveau régional, nous avons la gouvernance, la préfecture, le conseil régional et leur démembrement qui sont les représentants des autorités au niveau national. Ils mettent en œuvre au niveau local les recommandations nationales mais identifient aussi les problématiques sectorielles pour leur meilleure prise en compte dans l'élaboration de la politique nationale.

Par rapport à notre problématique de développement rural, les principaux bras techniques sont les services régionaux et départementaux de développement rural ainsi que les inspections régionaux et départementaux des services vétérinaires. Les premiersassurent les missions régaliennes de suivi du secteur agricole, d'élaboration des propositions, des politiques et programmes agricoles et effectuent le suivi et l'évaluation des réalisations dans le secteur agricole. Ils ont aussi un rôle de formation et de sensibilisation des acteurs autour de l'agriculture et de l'élevage en général et de l'entreprenariat rural en particulier. Les seconds ont pour principale mission l'exécution des programmes et projets de développement de l'élevage dans région qui leur sont directement assignés par le Ministère de la tutelle. Elles sont aussi chargées de l'élaboration de base de données sur l'élevage, de l'identification des couloirs de transhumances, de faciliter la mise en place des organisations d'éleveurs et de jouer un rôle clef dans la constitution du fonds d'appui à la stabulation. En effet, ces structures travaillent en relation avec des sociétés de développement, des projets et des ONG qui sont dans leur zone d'emprise. Ces derniers s'activent généralement sur des problématiques spécifiques et peuvent venir ainsi en appui à la résolution de certains problèmes. L'importance et l'intérêt de cette diversité d'acteurs sont la complémentarité économique et technique. En effet, les services décentralisés sont caractérisés par leur déficit en moyens humains, financiers et techniques.

Les sociétés de développement rural interviennent généralement sur une filière pour améliorer la base productive en favorisant la structuration de celle-ci. Elles insistent sur les investissements structurants, facilitent l'acquisition d'intrants et organisent la commercialisation. Toutes ces actions se font en relation avec les organisations paysannes. Une autre fonction de ces sociétés est le conseil mais aussi l'appui technique à travers un quadrillage de leur zone d'action par des techniciens en relation avec les producteurs.

Les projets et ONG sont très présents dans la zone d'étude. Ils travaillent en mutualisant leurs moyens (financiers et humains) et/ou en complémentarité avec les différentes structures décentralisées et les sociétés de développements. Toutefois, leurs actions sont localisées dans l'espace et dans le temps avec des problématiques bien identifiées.

Le programme *Yaajeende* est surtout mis en œuvre pour lutter contre la malnutrition en s'appuyant sur des moyens humains et de techniques agricoles pour atteindre cet objectif. Pour

ce faire, des informations sur les meilleures pratiques en matière de nutrition, des conseils aux organisations de producteurs sur les produits alimentaires à cultiver sont développés par le biais de cellules de veille stratégique ou à travers des outils comme le «pass on the gift» qui consiste en un transfert de bétails de familles en familles afin de réduire leur vulnérabilité. Un autre projet, le PROGEDE a pour objectif d'assurer un approvisionnement durable des ménages en combustibles ligneux sur la base de l'aménagement participatif des formations forestières et la diversification dans l'utilisation de sources d'énergie alternative (bioénergie, solaire, butanisation, ….). Le PAPIL qui intervient sur la petite irrigation axe son intervention sur les aménagements hydro-agricoles et pastoraux durables et sur le renforcement des capacités et l'appui aux organisations communautaires de base comme la plupart des projets ou programmes. D'autres programmes comme le GRDR mettent l'accent sur le développement local et la citoyenneté alors qu'ENDA LEADS met l'accent sur les questions de développement en entreprenariat rural mais sur les questions en rapport avec le changement climatique. Cette diversité d'acteurs et de moyens sont généralement spécifiques à certaines zones et on note une faible mutualisation des actions.

Au niveau des collectivités locales, la capacité à fournir des informations, des ressources et d'offrir des formations aux populations diffère d'une collectivité à l'autre. Les priorités accordées à l'atténuation des effets du changement climatique ne sont pas les mêmes pour toutes les collectivités locales.

Même si au niveau des communautés rurales, l'accent semble être mis sur la sensibilisation et la formation sur les effets du changement climatique, ces différents aspects ne sont pas des priorités ou inscrites comme des activités avec des objectifs à atteindre. Ils sont noyés dans des orientations plus globales (niveau pays) et sectorielles (agriculture, élevage, environnement) ou pris en charge dans les activités de projets et programmes de développement. Or, ceux-ci sont le plus souvent à court terme et vise très peu de cibles.

Leur capacité à fournir des informations est le plus souvent limitée par l'absence de politiques spécifiques et de ressources financières. Les compétences spécifiques en matière d'animation et de sensibilisation sur les effets du changement climatique ne sont pas réunies chez la plupart des collectivités locales.

Pour les commerçants, la capacité à fournir des informations est variable selon l'expérience et le type de commerçants (produits agricoles ou d'élevage). De façon générale, leur capacité est limitée.

II. PRISE DE CONSCIENCE ET RÉPONSES PAR RAPPORT AUX TENDANCES ET AUX CHOCS CLIMATIQUES.

Il a été noté à travers les interviews, une prise de conscience des acteurs sur la réalité du changement climatique. Dans le domaine de l'agriculture, il se manifeste particulièrement par un retard de l'hivernage et par une fréquence de longues pauses pluviométriques (15 jours en moyenne). De plus, même avec la faible pluviométrie, il est constaté une récurrence des inondations surtout avec la remontée du niveau du fleuve qui dépasse généralement son seuil critique de dix mètres. La persistance de la saison sèche froide a un impact négatif aussi sur la culture du riz de contre saison car empêchant souvent la double culture. Cependant, différentes réponses sont apportées par ces services départementaux ou régionaux par le biais d'actions de

sensibilisation et de prévention en relation avec d'autres structures qui travaillent sur le changement climatique (ENDA LEADS). On note aussi la mise place de cellules de lutte contre la malnutrition avec l'appui du programme alimentaire mondial (PAM) et de la FAO pour venir en aide aux populations qui sont directement victimes du changement climatique. D'autres mesures sont également prises, comme la mise en place, au niveau des Socités Régionales de Développement Rural (SDDR), d'un service régional de la météo pouvant aider à la prise de décisions mais aussi comme système d'alerte précoce. D'autres actions ponctuelles de lutte contre les inondations sont menées par la création de digues protection avec des sacs de sables pour protéger les champs. La SAED mène des actions plus durables avec le recrutement de techniciens qui travaillent sur les problématiques du changement climatique avec l'appui d'Africa Rice.

Les responsables de l'élevage ont plus insisté sur la sécheresse et la hausse des températures qui peuvent affecter le tapis herbacé et la disponibilité de l'eau qui sont essentiels pour le bétail. La baisse de la pluviométrie et sa mauvaise répartition ont été aussi relevées ainsi que le développement des feux de brousse surtout dans la zone sud de l'étude. Ces phénomènes sont responsables des transhumances qui favorisent souvent des pertes importantes.

Pour mieux prendre en considération ces problèmes, un partenariat est noué avec le centre de suivi écologique (CSE) pour la cartographie des pâturages qui servira d'outils d'aide à la décision et dans l'identification des couloirs de transhumance. De plus, il a été mise en place des unités pastorales pour mieux développer la capacité de résilience des éleveurs en cas de chocs climatiques. Il est constaté aussi des activités de sensibilisation et de conseil à l'endroit des agropasteurs pour mieux comprendre la réalité du changement climatique, en insistant sur le développement de nouvelles stratégies adaptatives (culture fourragère, embouche de ruminants, insémination artificielle, …). Ces activités sont généralement menées avec des partenaires au développement dont l'USAID).

Au niveau des programmes, projets et ONG, on note une grande prise en considération du changement climatique, ce qui dicte la plupart de leurs actions opérationnelles et de leur appui de capacitation au profit d'acteurs locaux.

Au niveau des collectivités locales, on note également une prise de conscience du changement climatique, mais les réponses apportées en rapport aux chocs climatiques sont limitées et se résument aux reboisements et à la maitrise de l'eau, principalement dans un but d'alimentation. Des politiques hydrauliques tendant à augmenter les productions agricoles et d'élevage sont quasi absentes.

Dans certaines collectivités locales (*Dougué*), des solutions radicales sont avancées : déplacement des populations. Ce qui dénote quelque part, l'ampleur du phénomène et le degré de vulnérabilité des populations.

Chez les commerçants de manière générale, on note une forte conscience au choc climatique qui réduit selon eux, la disponibilité des produits et sous-produits agricoles et d'élevage et augmente leur caractère périssable et leur qualité.

Une des réponses apportée est la réduction de leur capacité d'approvisionnement pour réduire les pertes liées au transport et au stockage. Ce qui a une incidence sur la satisfaction de la demande des produits concernés.

III. DEGRÉ DE PRISE DE CONSCIENCE ET DE COMPRÉHENSION DU CHANGEMENT CLIMATIQUE.

Tous les acteurs sont conscients des modifications qui se sont opérées dans le temps et dans l'espace dans la zone d'étude. Cependant, il est constaté que les acteurs sont relativement attentistes par rapport à ces phénomènes. Très peu d'initiatives endogènes de grandes envergures sont observées aussi bien par les populations locales que par les structures. Des initiatives sectorielles seulement sont observées avec très peu d'impacts même au niveau local. En effet, les acteurs sont plus sensibles aux chocs ponctuels auxquels il est apporté une réponse localisée sans pour autant avoir une vue plus globale.Les principaux conventions et programmes nationaux et internationaux de lutte contre le changement climatique (PANA, CCNUCC) sont très peu connus, voire ignorés par des responsables de service. Ainsi, leurs principales recommandations ne sont pas prises en considération dans l'élaboration des activités au niveau local, ce qui constitue une contrainte pour lutter contre les effets négatifs du changement climatique dans le long terme.

Il y a une prise de conscience effective du changement climatique par les projets et ONG qui se traduit par la mise en débat particulièrement sur l'adaptation au changement climatique par les populations locales et la mise en place d'aménagements spécifiques. Cependant, il y a très peu de grands programmes financés spécifiquement pour la lutte contre le changement climatique. En effet, pour la deuxième phase du PROGEDE, il y a aura l'introduction du volet changement climatique dans le programme avec dans sa mise en œuvre le recrutement d'un spécialiste et l'établissement d'un budget spécifique réservé au volet changement climatique.

Si certaines communautés rurales sont fortement conscientes des effets du changement climatique, d'autres les minimisent et l'imputent à des phénomènes naturels normaux, qui se sont toujours répétés. De ce fait, il ne représente pas une priorité pour la sensibilisation des populations et la mobilisation de ressources. D'autres contraintes (santé, agricoles) semblent plus prioritaires. Mais, en se focalisant sur l'unanimité des réponses sur l'augmentation des températures, il importe de dire que les populations ne sont pas suffisamment sensibilisées sur les effets du changement climatique. Certaines populations ne se focalisent que sur le court terme et de ce fait ne peuvent voir et apprécier les effets du changement climatique à leur juste importance.

Les commerçants ont une idée vague du changement climatique, même s'ils arrivent à attribuer certains effets (changements) à ce phénomène. Pour eux, les effets du changement climatique tels que les inondations ont rendu difficile la conservation des produits et ont des impacts négatifs sur les infrastructures routières (mauvaise route), allongeant ainsi la durée du transport des produits.

IV. PROGRAMMES ET ACTIONS ACTUELLES EN RAPPORT AVEC LE CHANGEMENT CLIMATIQUE

Dans l'élaboration des plans locaux de développement (PLD), le changement climatique est pris en considération dans le volet de gestion des ressources naturelles et environnement. Dans la pratique, les problématiques en rapport avec le changement climatique ne sont pas prises en compte dans la majorité des programmes mis en œuvre. La principale contrainte est l'ignorance des programmes et de leurs conclusions aussi bien au niveau national qu'international sur le

changement climatique. De plus, les programmes d'action en rapport avec le changement climatique ne sont pas pris en compte dans le budget du service et très peu (ou pas) de directives provenant des ministères de tutelle ne sont prises pour être appliquées. Néanmoins, il est constaté que ces acteurs échangent sur la thématique lors d'ateliers auxquels ils sont conviés avec les partenaires (ENDA LEADS, FAO, …). Toutefois, comme relevé dans le paragraphe précédent, quelques actions ponctuelles sont menées surtout en rapport avec l'adaptation, la distribution de semences à cycle courts, la construction de barrages colinéaires.

La SAED semble plus informée sur les programmes (programme sur l'approche territoriale pour le changement climatique- TACC, participation à des ateliers) mais demeure peu informée sur les grands programmes (PANA, CCNUC). Il a été relevé aussi que la SAED intègre le volet changement climatique dans sa budgétisation (moins de 10% du budget de la société) sous forme de recherches et Développement.

Les programmes du PANA et du CCNUCC sont bien connus par la plupart des projets et ONG mais ces deux documents ne sont pas pris en compte dans l'identification de leurs objectifs mais à l'avenir certaines structures pensent intégrer les conclusions de ces deux documents pour l'élaboration de leur programme sur le changement climatique. Cependant, différentes formes d'adaptation qui ont fait leur preuve ailleurs sont proposées dans des environnements similaires pour favoriser une gestion durable des ressources. Ainsi, on peut relever la mise en œuvre de zaï manuels et mécanisés, l'introduction de variétés à cycle court, les cordons pierreux, la séquestration de carbone, …

Au niveau des communautés rurales enquêtées, la présence de projets ou programmes d'atténuation des effets du changement climatique n'est pas répertoriée. Les projets et structures présentes (SAED, PAPIL, ENDA) ne sont pas spécifiquement orientés sur l'atténuation des effets du changement climatique mais renferment néanmoins des activités en liens au changement climatique.

En ce qui concerne les commerçants, l'ignorance des actions entreprises est manifeste. Pour eux, les programmes et projets mettant en œuvre des actions de lutte contre les effets n'existent pas ou ne sont pas suffisamment opérant pour impacter sur la vie des populations.

V. CAPACITÉS D'ANTICIPATION ET DE PLANIFICATION PRENANT EN COMPTE LES TENDANCES ET LES RISQUES CLIMATIQUES POUR FAIRE FACE AUX BESOINS FUTURS.

Au niveau des collectivités locales, la capacité d'anticipation et de planification en rapport aux besoins futurs est très limitée du fait du manque de compétences spécifiques dans ce domaine, de politiques locales et de ressources financières. Les entretiens ont montré que les collectivités locales dépendent beaucoup des politiques étatiques globales. Elles offrent très peu de politiques ou d'initiatives locales en rapport aux effets du changement climatique.

Dans certaines collectivités locales (Sinthiou Fisa), la capacité d'anticipation et de planification est ressortie dans les entretiens mais pour les dirigeants, les actions en matière de lutte contre le changement doivent inclure la participation et l'appropriation des populations locales.

Les commerçants, à l'image des collectivités locales, ont des capacités d'anticipation limitées. Du fait de la baisse des rendements agricoles et de la baisse de la taille du cheptel, les

commerçants contractualisent le plus souvent avec des producteurs en faisant des avances de trésorerie ou en finançant une partie des dépenses familiales pour bénéficier d'un privilège sur l'approvisionnement en marchandises (produits agricoles surtout).

Une autre stratégie consiste à aller dans des zones très éloignées pour satisfaire leur capacité d'absorption de produits agricoles ou d'élevage.

À ce niveau, les acteurs recommandent d'agir sur différents leviers :

- Le premier concerne l'information, la sensibilisation et la communication au niveau des différents acteurs particulièrement ceux à la base. Il faudrait qu'il y ait une appropriation de la problématique sur le changement climatique pour qu'il y ait une conscientisation et une bonne compréhension des phénomènes du changement climatique aussi bien des autorités, des populations locales et des partenaires au développement ;
- Le deuxième levier concerne les mécanismes à mettre en place pour une pérennisation et la durabilité des actions à mener face à la diversité des chocs climatiques. Pour ce faire, il faut pouvoir bien identifier les besoins (capitaux physique, naturel, humain, social, financier) et de disposer d'une bonne analyse environnementale afin de pouvoir favoriser un développement durable ;
- Le troisième concerne la mutualisation des moyens pour mieux gérer les actions au niveau local en développant le partenariat public-privé. Le développement endogène doit être mis en avant pour favoriser la pérennisation des actions ou programmes.

CONCLUSION

La perception du changement du changement climatique et surtout de ses effets, diffère selon les populations et les acteurs de façon générale. Les structures étatiques et projets sont mieux au fait des réalités et des développements sur ces aspects que les collectivités locales et les populations, rurales surtout. Les politiques étatiques en faveur de l'environnement (PANA et CCNUCC) ne semblent pas touchées l'ensemble des collectivités locales ou sont méconnues et les actions ne sont pas mises en œuvre en fonction des besoins spécifiques de chaque collectivité.

Même si les acteurs deviennent de plus en plus conscients des effets du changement climatique, les capacités à fournir des informations, à mobiliser des ressources et à offrir des formations sont limités surtout pour les collectivités locales et les populations.

De façon générale, on note au niveau de la collectivité locale et des populations, peu de stratégies efficaces pour faire face aux effets multiples du changement climatique. Les réponses apportées ne s'inscrivent pas dans la durée.

En dernière analyse, il ressort que le Sud (Tambacounda et Bakel) semble moins touché par les phénomènes climatiques que le Nord (Matam, Kanel).

Les actions entreprises en vue de lutter contre les effets du changement climatique sont plus visibles dans le Sud, du fait peut être de la présence de projets comme le PAPIL et le PROGEDE.

Dans les communautés rurales situées au nord, les assistants communautaires (Ascom) ont une perception plus claire des chocs et du changement climatique que les présidents de communautés rurales (PCR). Par contre, au sud les PCR ont une perception assez claire des chocs et du changement climatique et s'activent beaucoup à la lutte contre ce phénomène.

Le manque d'équipements et de personnels constitue le principale problème des institutions dans l'ensemble des départements.

ANNEXES

KII Reporting Guide

Date de l'interview :

Nom de la communauté rurale/département/projet/louma:

Lieu de l'interview :

Nom de la(les) personne(s) interrogée(s):

Titre:

Nom de l'enquêteur :

Nom du rapporteur :

1. Capacité réelle de fournir des informations, des ressources et de la formation au niveau local
2. Prise de conscience et réponses par rapport aux tendances et aux chocs climatiques.
3. Degré de Prise de conscience et de compréhension du changement climatique.
4. Programmes et actions actuelles en rapport avec le changement climatique.
5. Capacités d'anticipation et de planification prenant en compte les tendances et les risques climatiques pour faire face aux besoins futurs.
6. Constats spéciaux de l'équipe par rapport à l'étude.

Tableau répartition des institutions interviewées :

	Matam	Kanel	Bakel	Goudiry	Total
Services Techniques	3	2	2	1	8
Communautés Rurales	4	3	2	5	14
Projets	2	1	2	2	7
Commerçants	4	2	3	2	11
Total	13	8	9	10	40

Tableau récapitulatif

Département	Nom des enquêtés ou structures enquêtés	Nom du Fichier envoyé	Type de document	Type de l'interview
Matam	DRDR Matam	Fiche DRDR Matam	Rapport	Service technique
	Yaajeende	PTA 4	PTA 4	
	Mme Fatou Sall	Rapport Yaajeende	Rapport	Project
	Amadou Thiam/PCR Ogo	PCR Ogo	Rapport	CR
	Balde/Chef du CADL Matam	RAPPORT CADL Matam	Rapport	Service technique
	Balde/Chef du CADL Matam	Lutte contre les inondations	Document Additionnel	
	Ndong/Dir.Regional Elevage	Rapport direction de l'élevage	Rapport	Service technique
	Sene/Adjoint du gov	Services Régionaux	Rapport	Service technique
	Gueye/Dir. De DRDR		Rapport	
	Demba Lamine Ba	Louma civol	Rapport	Commerçant/ produits maraichers
	Babacar Niang	Commerçant Matam	Rapport	Commerçant/ Céréales
	Diop/produce trader	Louma Thilogne	Rapport	Commerçant/ Produits maraichers
	Timera/PCR	PCR Bokidiawe	Rapport	CR
	Diagne/Assistant Communautaire			
	Abdoulaye Moussa Ndiaye	PCR Oréfondé	Rapport	CR
	Directeur SAED/Matam	SAED	Rapport	Service technique
		SAED/envoie	Document Additionnel	
	Demba Lamine Ba	ASCOM Nabadji civol	Rapport	CR

Département	Nom des enquêtés ou structures enquêtés	Nom du Fichier envoyé	Type de document	Type de l'interview
	Seydou Djibo Thimbo	Commerçant bétail Thilogne/Matam	Rapport	Commerçant
Kanel	Mamadou Dia	CR Ouro Sidi	Rapport	CR
	Mamadou Wone	PCR Aouré	Rapport	CR
	Omar Gueye	Service Agriculture Kanel	Rapport	Service technique
	Mamadou Saliou Diao	Service élevage Kanel	Rapport	Service technique
	Alhassane Dia	Arouna Dia/ Exploitant Privé	Rapport	Privé
	Maguène Diop	Ascom Bokéladji	Rapport	CR
	Mansour Béye	Commerçant Orkadiéré (Kanel)	Rapport	Commerçant/Céréales
Bakel	Thierno Bal	ENDA LED	Rapport	Projet
		ENDA LED/Document	Document Additionnel	
		ENDA LEAD/ Glossaire	Document Additionnel	
		GRDR/Bakel	Rapport	Projet
		Louma Orkadiéré	Rapport	Commerçant
		Service élevage Bakel	Rapport	Service technique
		SDDR Bakel	Rapport	Service technique
	Ibrahima Niang	Commerçant Bakel	Rapport	Commerçant
	Fati Gandia	Loumo Bondji	Rapport	Commerçant/ Produits maraichers
	Samba Demba Diawara (SDD)	Commerçant Bétail Bondji	Rapport	Commerçant
Goudiry	Haby BA	Louma Balla (Goudiry)	Rapport	Commerçant/ Produits maraichers
	Khady Ndémane	Commerçante Goudiry	Rapport	Commerçante/ Céréales
	Abdoulaye Ka	PCR Sinthiou Mamadou Boubou	Rapport	CR
		PCR Koar	Rapport	CR

Département	Nom des enquêtés ou structures enquêtés	Nom du Fichier envoyé	Type de document	Type de l'interview
		CR Dougué	Rapport	CR
	Sédar Ngom	PAPIL/Goudiry	Rapport	Projet
		PAPIL/PTABA_2013	Document Additionnel	
	Dialy Diankha	PCR Komoti	Rapport	CR
	Agnès Daba Thiaw	PROGEDE/Goudiry	Rapport	Projet
	Ibrahima Thiam	Ascom Gabou	Rapport	CR
	Ortence Thiaba Mbengue	ASCOM Sinthiou Fissa	Rapport	CR
	Seydou Dieng	PCR Bouynguel Bamba	Rapport	CR
	Seydou Ba	SDDR Goudiry	Rapport	Service technique

ANNEX S. ASSESSMENTY OF CLIMATE CHANGE VULNERABILITY IN EASTERN SENEGAL: PRESENTATION AND ANALYSIS OF FOCUS GROUP RESULTS

This report was prepared by Mamadou Baro under subcontract to Tetra Tech ARD.

EXECUTIVE SUMMARY

This report summarizes digitally recorded field notes from focus group discussions in the North and South of eastern Senegal, where two multidisciplinary teams conducted in-depth research on the impact of climate change vulnerability in that area. The study is based primarily upon community and key informant responses to climate change, livelihood vulnerability, and livelihood adaptation strategies and practices that have developed in response to climate change. The report includes four major sections: this Executive Summary; Methodology; Findings (including description and background, dominant livelihood types, and major trends in the North and South, dominant perceptions of climate change, sketches and uniqueness of surveyed villages, women and climate change, adaptive strategies and practices, variations in strategies between North and South, major constraints, community preparedness, and community views of outside interventions); and a Conclusion.

According to key informants, the surveyed villages in the North and South of Eastern Senegal constitute some of the poorest and least food-secure areas in Senegal. Villagers in the study area historically have adapted to climatic variability by practicing diversification, mobility, and migration. However, as focus group discussion informants pointed out, there exists more climatic variability and uncertainty today than 20 years ago, and traditional strategies that have been utilized for decades are often perceived to be no longer viable. In this study, the most significant findings include the types and directions of diversification, mobility, and migration as well as how these elements relate to climate, how diversification has changed during the past 20 years, and how households practice different livelihood strategies and innovate according to their particular circumstances.

The study focuses on rural livelihoods that primarily depend on livestock and rain-fed agriculture. One key finding concerns how villagers diversify their opportunities by employing a combination of basically three, rather than the formerly one or two, widespread livelihood strategies to make a living. In both the surveyed North and South, farming households rely heavily on animal production; additionally, pastoral households invest more heavily in agriculture, especially in *maraichage* (vegetable gardening). Exhibiting strong resilience in their adaptation to changes in environmental and social patterns with the addition of migration, villagers in both regions have developed a three-legged livelihood system that ensures livelihood when one or more systems fail.

Changes in livelihood strategy have transpired rapidly. Focus group informants noted that 20 years ago, pastoralism was the dominant livelihood system in the North, while rain-fed agriculture was more dominant in the South. Many informants reported that livestock ownership is becoming more generalized throughout the two regions, and vegetable gardens are becoming more commonplace.

However, as informants consistently pointed out, agriculture in eastern Senegal has been experiencing difficulties in the past 20 years due to fluctuating rainfall patterns, which villagers believe are caused by deforestation and "divine will." As mentioned by several focus groups, the total amount and distribution of rainfall; frequency of extreme events including heavy rainfall, flood, and drought; and the changes in temperature and the timing of the onset of the rainy

season have required major adjustments in livelihood strategies. For example, due to the unpredictability of rainfall, cotton plants (*liguédji*), indigo, and some varieties of sorghum (*niédiko* and *fela*) are no longer cultivated. To compensate for a growing population and the erratic rainfall's impact on yields, farmers have decreased fallow periods during the past 20 years. In some cases, fallow has been eliminated altogether. State subsidies for farming have ceased.

The predominant constraints to dependable and sustainable livelihoods in the two surveyed regions include lack of rainfall, unpredictability of weather patterns such as periods of drought with intermittent flooding, increase in crop predators, increase in bush fires, and population growth.

Villager informants noted that without migration as an adaptive strategy, livestock production would be a much less secure investment in the event of droughts such as those of the 1970s and 1980s. Key informants and focus discussion interviewees revealed that migration serves to increase resilience, because they use foreign remittances to rebuild herds. According to villagers, the rebuilding of herds after drought — often beginning with sheep and goats, which reproduce quickly — would be virtually impossible without these funds. This situation represents a change from the conditions reported by Santoir and other authors, who noted that herders were hit hardest by the severe droughts of 30 and 40 years ago, because, unlike a farmer's land, their capital was totally decimated. The subsequent rise in migration has substantially increased herder resilience as part of the three-legged strategy of agriculture, livestock production, and migration.

Most informants reported that rainfall varies so much that it is difficult to determine any consistent trend; it is either too much rain or not enough rain, with flooding and dry spells, increased temperatures, and stronger winds and dust storms. But in the context of declining agricultural production and healthy animal feed, most villagers emphasized the decline in rainfall. Water was, therefore, the most important concern that focus group interviewees expressed. Scarcity of water and water management systems, they said, constitutes the most limiting factor in all forms of both farming and livestock production.

While all of the surveyed villages currently engage in livestock production, climate change also presents major challenges to livestock management. For example, focus group discussants stated that when there is too much rain during the rainy season, sheep are at risk of death; sheep survive better in the dry North. According to informants, climate change also has negative effects on poultry, particularly chickens. In women's focus groups it was repeatedly noted that increasing heat has had a drastic effect on chickens, including the onset of a new, so-called "chicken disease" that can completely wipe out household stock. This trend primarily affects the holdings of women, whose small stocks disappear overnight or within two or three days.

Bush fire in Senegal. Source: Mamadou Baro

According to villager recollections, prior to twenty years ago, only a minority of villagers in the surveyed areas had cattle and small ruminants. Now almost all households in both regions have cattle, and the number of animals has doubled over the past two decades.

Many grass species have disappeared due to lack of precipitation and bush fires, and some informants believed that this is the reason that their livestock is not as healthy as it was 20 years ago. Village cattle will range as much as 30 kilometers from the village during the dry season in search of pasture; in recent years, an increasing number of bush fires have decimated lands near villages.

Cattle theft also has become an increasing problem, and villagers who can afford it hire professional shepherds to guard against cattle thieves.

As livestock become more capital intensive, there seems to be a trend in wealth concentration in livestock production in both regions, one of which seems to be creating a greater divergence between rich and poor. The concentration of wealth and resultant economic inequality is fueled by immigration, which brings with it both monetary funds (with remittances going primarily into livestock) and technological inputs such as animal traction and new plows and seeders to cultivate fields. These innovations reduce workloads and increase the practice of reducing the fallow period. Only wealthier households can afford veterinary services and *rakkal* (a commercial feed), which villagers say have become increasingly necessary. Many of those households receive remittances from long-term and permanent migrants, primarily young men.

Women are the most vulnerable to the impact of climate change due to their significant role in providing food and other necessities for their families. In all of the 15 villages, up to 75 percent of the population is women and children. Women are in charge of household and village affairs while many of the men are away, and women bear the burden of most of the work – childbirth, childcare, hauling water, gardening, livestock care, cooking, cleaning, walking long distances for trade and medical assistance, and so forth. Female informants often noted that they findi it more difficult to cope with rising food prices and the increasing demand for food as their families grow, noting that village populations have almost doubled in the past 20 years in spite of out migration. And since migration is predominately a strategy men employ, many villages are populated primarily by women who have to do their traditional share of the work in addition to the work of the men. Yet, while women have become increasingly central to livelihood systems in the region, due to the absence of the men and the importance of *maraichage* (primarily women's gardens), women are more vulnerable and remain marginalized, with limited access to resources such as land and credit.

Key adaptive strategies and practices in response to climate change in both regions include diversification (such as planting multiple crops or adding livestock production) innovation (using new types of soils or fields, abandoning or adopting crops or varieties of vegetables, new practices and technologies), mobility and migration, communal pooling of resources, and the increasing significance of local markets for the exchange of goods and services.

Finally, the study supports a vision that puts people's experiences of climate change on the ground at the center of discussions of climate change policy and recommendations, and must therefore include women as key research subjects, informants, and primary change agents.
Methodology

Focus group discussions were held with villagers in groups but also included extensive discussions with individual participants. Semi-structured questionnaires were used to obtain standardized feedback while permitting participatory discussions in which respondents could

openly share their perspectives. The standardized topical outline of critical questions was distilled from the scope-of-work objectives.

The two main objectives of the focus group discussions were to provide a context for the results of the concurrent household survey and to gain an understanding of how people have responded to changes in the climate over the past 20 years at the household level as well as in their cropping and livestock systems. Focus group discussions also included information about the past 20 years of evolution in livelihoods.

Discussion guides thus began with a general discussion of the villages, focusing on productive activities, followed by descriptions of changes in the village during the past 20 years. The guide then focuses on specific changes in farming and raising livestock. Reasons for each change were solicited, as were reasons for changes in the amount of investment in the two livelihood strategies. As a final topic, the guide included a discussion of the constraints to practicing agriculture and raising livestock. (Annex D contains an example of the final focus group guide.)

As noted above, the study focuses on rural livelihoods that depend on livestock and rain-fed agriculture. The population resident along the river, not included in the study, was excluded from the sample frame. Because the focus was on vulnerable rural households, the sampling frame also excluded settlements larger than 2000 inhabitants.

A total of 15 villages were randomly selected, seven from the two northern departments of the study zone (Matam and Kanel) and eight from the southern two departments (Goudiry and Bakel).

An initial trip to contact villages was conducted from October 21 to 28, 2013. During these initial contacts the purpose, timing, and nature of the fieldwork was explained, and basic information was collected concerning each village and department. At this point, two villages were excluded because they were found to be inaccessible and were replaced by two villages from those identified for this purpose. (For more information, see assessment Annex F, "*Rapport de mission sur la prise de contact et la prospection des villages retenus pour l'étude*").

During the week of November 11, the ARCC assessment team trained 12 enumerators, two supervisors, and four facilitators to conduct the survey and focus groups. Trainees piloted the instruments on November 16 and completed fieldwork on December 5. Two days were allotted for each of the 15 survey villages, and in a number of instances the teams spent the night in the village.

Upon arriving in each village, supervisors of the fieldwork teams conducted introductory meetings with village chiefs, notables, and other interested parties, during which the purpose of the research as well as the timing and organization of the interviews and focus groups were explained. At this point, they also collected and completed lists of the village households. Six of the original 15 villages had less than 30 households – three in the Northern sub-zone and three in the South. Households and focus group participants were added from an additional six neighboring villages.

Focus groups were conducted concurrently with the surveys. Supervisors explained that participants in the men's and women's focus groups should be adults who know the village and represent the diversity of the village, coming from the various neighborhoods, ethnic groups,

livelihood groups, and wealth categories. Handwritten notes from each focus group were drafted into reporting forms on laptops in the evening or the following day. A total of 421 people participated in the focus group discussions, 207 of whom were men and 214 women. (For a more complete discussion of methodology, see Annex B.)

FINDINGS

Description and Background

This section provides a brief description and background of the surveyed villages, dominant livelihood systems and trends, perceptions of climate change, sketches and uniqueness of surveyed villages, women and climate change, adaptive strategies and practices, variations in strategies and constraints between the North and South, major constraints identified by community members and suggested outcomes, community perceptions on climate change, and community views on outside interventions.

Table 1 is a summary of the population and dominant livelihoods of surveyed villages in the North and South. A comparison of these figures with the 2002 census indicates that during the past 20 years, population has increased in all surveyed villages and doubled or tripled in most. This growth reflects national trends; a high birth rate per 1000 (41.7 percent); and a high rate of annual population increase (3.18 percent). Further, life expectancy at birth has improved from 48.7 to 63.4, while the death rate per 1000 is 9.9 (Senegal Ministry of Planning and Cooperation, Directorate of Human Resources, 2013). Some villages also have received immigrants from Mauritania, Guinea, and Mali.

The table also shows that, despite the growth of livestock raising, in most villages agriculture continues to be seen as the dominant livelihood.

TABLE 1: ESTIMATED POPULATION AND DOMINANT LIVELIHOODS IN THE SURVEYED VILLAGES

Village	Pop. 2013[2]	Self-Reported Dominant Livelihoods[3]		
		First	Second	Third
North				
Asnde Balla	1,638	Agriculture	Livestock	Emigration
Kirire I	893	Agriculture	Livestock	Emigration
Hontorbe	579	Agriculture	Construction Work	Livestock
Thiancone Hiraye	1,887	Emigration	Livestock	Agriculture
Ouro Cebo	336	Livestock	Agriculture	Forest Products
Ouro Silamaka	1,303	Agriculture	Emigration	Livestock
Boulone Samba Djadji	746	Agriculture	Livestock	Emigration
South				
Sinthiou Madina	500	Agriculture	Elevage	Emigration
Boulel	550	Agriculture	Livestock	Emigration
Mbankanabe	533	Agriculture	Elevage	Emigration
Samba Kolo	719	Agriculture	Livestock	Gathering
Boynguel Bamba	816	Agriculture	Livestock	Commerce
Gambi	500	Agriculture	Livestock	Emigration
Koar	3,000	Agriculture	Elevage	Charcoal production
Godioyel	150	Agriculture	Livestock	Commerce

According to key focus group discussants, the surveyed rural northern and southern zones are of the poorest and least food-secure areas in Senegal. Even in years with acceptable rainfall, domestic food production provides only a fraction of food needs, primarily due to limited arable land in the North and traditional low-yield production systems in both regions.

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[2] Estimated population according community interviews and focus group discussions.

[3] Self-reported responses from community and focus interviews.

Households have traditionally coped with food shortages by relying on cash earned from the sale of livestock and livestock products and remittances from family members living abroad.

A series of shocks since the early 1970s have eroded villagers' assets. In both areas, high malnutrition levels directly link to increased food insecurity and a fragile environment. Informants consistently noted that this structural food insecurity results from severe and precarious climatic conditions reflected in low agricultural soil fertility, low agricultural productivity, and the degradation and diminishing of natural resources (water, vegetation, and food sources). The impact of the food situation, people said, is reflected particularly in the health of the population, household nutrition, and access to potable water and to energy.

Dominant Livelihood Types and Major Trends in the North and South

According to Table 1, the dominant livelihood systems found in the surveyed villages are agriculture, livestock raising, migration and commerce. The ways these systems are combined enable villagers to adapt to erratic climate conditions, resource degradation, bird and insect predators, and changing social and global conditions including changes in policy and outside intervention. It is the types and directions of diversification, mobility, and migration in response to climate change that constitute the study's most significant findings.

Agricultural Production

Twenty years ago Samba Harouna, 52, a recently returning migrant from France, and his 550 neighbors, made their living from sorghum, corn, millet, groundnut, and cowpea. "Boulel was a beautiful village with lots of water and green everywhere… Now, we have to limit our needs for water because it is becoming an expensive commodity," he recalled.

"I'm sad that to see that our dominant livelihood system — agriculture — is on the verge of collapse. Life is no longer the same and my people have to adapt or perish. I am also sad because I cannot teach my children what my ancestors taught me – knowledge of the land and what can grow on it, and about the fauna and flora," said Samba, one of the lucky villagers who found a way to migrate to Europe in the 1980s.

According to focus group discussants, although agriculture has been a major subsistence and income strategy during the past 20 years, such is no longer the case. In the context of discussions regarding the negative effects of climate change, both northern and southern informants repeatedly complained about the lack of reliability and profitability of agriculture. Villagers believed that this problem is primarily linked to climate change in terms of unpredictability of rainfall, reduced duration of the rainy season, and increased temperatures. Other contributing factors are decreased productivity of soil, an increase in bush fires, bird and insect predators, and trespassing of animals into the fields.

What follows is a description of villagers' main agricultural activities, including the main crops grown and the seasonal timing of activities. Both in the North and South, crops grown during the rainy season include millet, okra, peanuts, hibiscus, and *niebe*; in the dry season villagers cultivate vegetable crops such as hibiscus, carrots, okra, chili, lettuce, eggplant, tomatoes, and cabbage. The beginning of the agricultural calendar starts during April and May with the construction of fences by villagers and the clearing of the land using axes, machetes, and rakes. After the arrival of the first heavy rain in late June to early July, farmers begin planting using

animal traction (donkeys and horses) or by hand using a hoe called *jindagou* (a Pulaar term). During July and August, the weeding is done with plows pulled by donkeys and horses, or with traditional hoes handled by men. From September onward, villagers begin efforts to guard against birds. At the end of September and early October, crops reach maturity and are harvested; this period can last up to two months, from October to November. *Niebe*, *follere* (hibiscus), and watermelon are often intercropped with millet, sorghum, and peanut.

Transport of harvested produce is done by *charrettes* (carts) pulled by horses or donkeys, or brought with bowls carried on women's heads. Then these products are stored in granaries, without post-harvest treatment. Most production is for household use; in many cases, households can barely make ends meet. On the rare occasions that there is excess production, products are sold in local markets. Growing vegetable crops (*maraichage*) — primarily by women — is a new trend in both the North and the South; however, the availability of and access to water limits the viability of household gardens.

Among the new technologies in agriculture brought in by migrants, the most important has been animal traction, which informants said was introduced in 2002 for pulling agricultural tools and machinery. When queried, villagers indicated that this practice has become self-sustaining. Another important technology is the practice of installing fences around the perimeter of fields to prevent the encroachment of predators and stray livestock. The latter represents a major innovation and a departure from traditional custom, as it has become the landowner's responsibility to protect his or her garden and livestock. This trend responds to the greater number of livestock and to the need for intensification of gardening, as well as to protect pasture. It is a trend towards privatization and an increased gap between the rich, who can afford to build fences, and the poor, who cannot.

Livestock Production

Focus group informants stated that 20 years ago, pastoralism was the dominant livelihood system in the North, and agriculture was dominant in the South, where some Fulani-s supplemented livestock production with small gardens. Today, due to difficulties in agricultural production, livestock production appears to be taking over as a major livelihood strategy in all surveyed villages. The main reared animals are cattle, sheep, goats, donkeys, horses, and poultry. Among these, sheep and goats are increasingly preferred due to ease of care, adaptability to climate change, and ease of sale. In general, during the rainy season, the animals remain in the village and use local pasture; during the dry season, herds must go farther afield in search of pasture – sometimes as far away as in Mali. According to focus group informants, due, for example, to lack of rainfall, deforestation, reduction of the fallow period, and population increase, natural feed sources consisting of highly nutritious plant matter have become depleted; in recent years, animals have come to require a generic type of supplemental feed, much like hay in the West, called *rakkal*, which is industrially produced and must be purchased at the market. This practice limits the viability of livestock production, because only the wealthier villagers, or those receiving migrant remittances, can afford supplemental feed and increasingly necessary veterinary care. The same holds true for hiring professional herders, as discussed below.

Villager informants noted that without migration as an adaptive strategy, livestock production would be a much less secure investment in the event of droughts such as those of the 1970s

and 1980s. Key informants and focus discussion interviewees revealed that migration serves to increase resilience, because they use foreign remittances to rebuild herds. According to villagers, the rebuilding of herds after drought — often beginning with sheep and goats, which reproduce quickly — would be virtually impossible without these funds. This situation represents a change from the conditions reported by Santoir and other authors who noted that herders were hit hardest by the severe droughts of 30 and 40 years ago, because, unlike a farmer's land, their capital was totally decimated. The subsequent rise in migration has substantially increased herder resilience as part of the three-legged strategy of agriculture, livestock production, and migration.

Migration Finances Both Livestock and Agricultural Production

Focus group discussants consistently pointed out the significance of remittances from migrants as income that producers use as key leverage to support their particular livelihood systems. Most reported that increasing numbers of migrants, and in fact most migrants, have been investing primarily in livestock, which seems to be the most lucrative investment and is perceived to carry less risk. Indeed, villagers repeatedly reported being discouraged by the increasing hardship and growing uncertainties of agriculture.

Participants in the focus groups reported three major forms of migration (by primarily young men): seasonal, long-term, and permanent migration, reinforcing what is known from other studies. Informants noted that it is primarily the long-term and permanent migrants who provide substantial remittances. In seasonal migration, young people leave the village after harvest to migrate to the different regions of the country to work as laborers or engage in small business ventures. In long-term and permanent migration, an often-large number of villagers migrate primarily to France. But the latter has become more difficult in recent years due to tighter European immigration requirements. In response to his trend, some migrants are starting to go to other African countries such as Congo, Ivory Coast, and Gabon. These migrants put into play numerous forces of change. One challenge wrought by migration is that young migrants returning to the village reportedly challenge the authority of the elders, refusing to herd animals or to work the land. Elderly villagers also thought that these young men practice "Western vices" such as smoking, drinking, and other negative forms of behavior.

Informants often noted that villagers diversify opportunities by employing a combination of these three different livelihood strategies to make a living. The old model of a primarily subsistence farming or pastoral livelihood clearly does not hold in the study area. Both in the North and South, farming households rely heavily on animal production, and pastoral households also invest more heavily in agriculture, especially in *maraichage*. Exhibiting an extraordinary resilience and innovation in adapting to livelihood insecurity, adding the advantage of migration opportunities to agriculture and livestock production, villagers have developed a three-legged livelihood system that ensures livelihood when one or more systems fail to produce. In both regions, people seek to take advantage of whatever opportunities they can find to make a living. These are important adaptations to changing climatic conditions and a rapidly changing and unpredictable social and natural environment. This trend can be clearly seen, for example, in the following villages: Thiacone Hiraye, Godiyel, and Sinthiou Madina in the South; and Kirere, Ouro Cebo, and Samba Kolo in the North.

Climatic Impacts on Dominant Livelihoods

The study found that in eastern Senegal, there are certain common characteristics of climate change between the North and South. These include (1) irregularity of rainfall; (2) persistent cycles of drought with increased instances of flooding; and (3) the disappearance of forests, which was linked in many focus group discussions to climate change. The researchers witnessed persistent community efforts in both regions to adapt to these changing conditions by modifying their agricultural and livestock practices and, often, lifestyles (for example through migration, which has significant effects upon village demographics and livelihoods). Climatic impacts on dominant livelihoods were consistently reported as follows in villages such as Ouro Silamakha, Mboulel, Asnde Ball, Hontorbe in the North, and Gambi, Koar, and Boynguel Bamba in the South.

According to key informants, 20 years ago pastoralism was the dominant livelihood system in the North, and agriculture was more dominant in the South. A major change in both surveyed regions is that livestock ownership is becoming more generalized throughout the two regions, and in both the North and South, vegetable gardens are becoming more common, as well. While there exist many similarities between surveyed villages in the North and South, there are significant differences between the two regions. While most villagers in the North and South can be characterized as vulnerable to climate change, what is striking in the South, in particular, is the extreme poverty of villages and the almost total abandonment by the State and its partners in terms of development projects. There are virtually no physical infrastructure or development projects in the surveyed southern villages. Despite the fact that the traditionally forested South has more rainfall than the North, lack of water constitutes the major concern for the surveyed communities. Due to more dominant erosion and a flatter topography in the South, there is also a great deal of water run-off and a lack of water harvesting structures. While water shortages due to climate change affect both regions, water in the South tends to be more poorly managed than in the North, with virtually no water harvesting techniques or technology (which could make a significant difference if applied). In many villages, to dig a well one has to go down almost 80 meters. The difficulty of digging a well constitutes a major constraint to *maraichage*, a form of small-scale farming by women that is viewed by many to be a viable alternative that provides greater food security and resilience to shock.

Key informants noted that livestock production has become a viable option in the South.

Surveyed communities in the South believe that households relying on livestock in the North are less vulnerable than they are in the South. There is greater mobility in the North, where pastoralism has been practiced for centuries. This reason is one of several for why some households in the South are now shifting their livelihoods to livestock raising as an adaptive mechanism to the consequences of climate change.

Even though many focus group discussants mentioned their hopes for the return of normal rainfall, rainfall has remained sparse. Discussion regarding the unpredictability of rainfall and rainfall fluctuations predominated in focus groups. Villagers in both regions noted that the duration of the rainy season is shorter than it was 20 years ago. There also seem to be two-to-three years of normal rainfall, which is then interrupted by a year of rainfall deficit.

Villagers see the increase in the incidence of wildfires, more prevalent in the forested South, as a dire threat to subsistence and to the environment. In the South, this increase in wildfires is

attributed to the migratory activities of groups of foreign (northern) transhumant herders, called *Agabe*, who have increased the amount of time, and perhaps the number of animals, pasturing in the South in response to the growing scarcity of pastures in the North. A key result of this trend is the depletion of the quality of southern lands, erosion, and periodic flooding.

Dominant Perceptions of Climate Change

Villagers reported that there is so much variation in rainfall that it is difficult to determine a consistent trend. In the North there are only two-to-three months of the rainy season, from June to September, with a longer dry season that can last for eight or nine months, from October to May. Sometimes there is too much rainfall in a short period of time, which creates floods; or rain is too little, creating drought. Villagers say they experience increased temperatures with fewer cold periods and stronger winds and dust storms.

Informants repeatedly noted a significant decline in rainfall during the past 20 years. Deforestation and "divine will" are believed to be the cause. In both regions, the prevailing sentiment of farmers is that they have been abandoned by the State and its development partners. This sentiment was somewhat more pronounced in the South.

Villagers in the North have observed that 20 years ago, the forest was denser and many plants and trees have disappeared due to village expansion and scarcity of rain that they believe is due to deforestation. Deforestation of nutritious herbaceous species specific to strong animal growth and lactation also has been repeatedly noted.

Water scarcity remains the major challenge for both regions. Many villagers have observed that village lands, animals, and crops have been increasingly exposed to cricket attacks, parasites and birds in recent years, and an influx of herders from the north. While the South used to be more densely forested than the North, and while rainfall has been more prevalent there, villagers in the South frequently expressed concern that the trend in the South is toward the deforestation, decrease in rainfall, and resource depletion that villagers see in the North. Twenty years ago, the forest surrounding Gambi, for example, was overflowing with many species of trees that have now disappeared; especially large trees formerly used for firewood and bamboo. Villagers say the cause is the misuse of forest resources — including drastic cutting and bush fires — believed to be due to human intervention. The consensus is that vegetation has disappeared due to drought and the increased harvesting of trees for home building, given the increase in population and influx of foreign transhumant herders – for example, herders from Guinea. Villagers also reported that transhumant shepherds have brought new diseases that have negatively affected livestock such that the owners of animals must now hire private veterinarians. (A vaccine costing 2,000 CFA francs can handle up to 30 heads of small ruminants.)

Sketches and Uniqueness of Surveyed Villages

This section highlights the major similarities in dominant views regarding surveyed village adaptive livelihood strategies and the effects of climate change on the ground. These views

serve as an apt summary of the trends in livelihood strategies that highlight frequently repeated points in both regions.

Major Similarities

Population Pressure

During the past 20 years, population growth has substantially occurred in both surveyed regions, while in some villages population has doubled or tripled (see Table 1).

Villagers reported this increase in population as being related to the persistence of polygamous households and increasingly early marriage. Another issue is the arrival of new migrants into the more environmentally natural resource-rich villages – for example, Guinean nationals or Malians in some localities (such as Koar). Twenty years ago, a massive exodus of Mauritanian Fulani refugees migrated to the surveyed areas because they were expelled from Mauritania. According to village informants, another explanation for population increase was that the implementation of expanded immunization programs and the construction of health facilities in nearby areas has contributed to reduced infant and maternal mortality.

Infrastructure and Outside Intervention

All of the surveyed villages have very little social and physical infrastructure, and most villagers feel that they have been abandoned by the State. In Hontorbé village, informants complained that the State is only present during elections when promises are made. The village does not have a health center, so people have to go to neighboring villages, Taiba and Ouroussogui, for medical treatment. The availability of schools in villages, in the North and South, is intermittent. In Hontorbé, children can enroll for secondary school only in the neighborhood villages (such as Taiba, situated 2 kilometers away). As in most surveyed villages, many changes have occurred in Hontorbé; however, the building of houses from cement, people said, remains one of the most important changes.

Some villages are along the main road, but many are not. In Gambi, a northern village, the roads are not paved and villagers walk through forest trails from one place to the next, and to attend weekly markets.

Few nongovernmental organizations (NGOs) are present in surveyed villages. In the northern village of Gambi, Peace Corps Volunteers dug two wells and helped women with gardening. NGOs such as ZARESE, which promotes women's gardening, and SET SERAL from Dakar, which builds latrines, are a positive presence in the Southern village of Hontorbé. But according to focus group women, the NGO *l'Association Solidarité Aissatou Gaye de Matam* allegedly stole 200,000 CFA from village women that had been collected from the women for the extension of their gardens. This is a typical case in both regions of what villagers call an "NGO *cartable*" ("empty briefcase"): making promises and taking money from the villagers in the guise of helping them organize, and then disappearing without paying back the funds that were collected from village women. This time is not the first instance in which women, who have so little, reported having been taken advantage of by such groups. Hontorbé women specifically asked the team to help them get their money back from this association.

Agricultural Adaptive Strategies

Agriculture is the dominant form of livelihood in all surveyed southern villages and is considered dominant in all but two northern villages (Table 1). In Silamakha and Mboulel, as in most villages surveyed in both regions, informants emphasized the failure of traditional rain-fed agriculture. Now, with the introduction of garden crops (*maraichage*) that are used both for household consumption and for sale, crops can be grown in the cold, dry season (usually by women, from December to February). But, villagers said, water sources are limited for the growth of *maraichage*. Sorghum was the number-one crop 20 years ago; however, now sorghum has been replaced by a variety of millet called *sunna*, which is more resistant to drought and does not attract bird and insect predators.

As in many villages, garden crops in Ouro Cebo and Thiewele are also grown in the short cold, dry season from December to February; corn and vegetable crops are the only new crops. Corn has replaced millet in most women's gardens, as it is more resilient to insect and bird predation. The main vegetable products in these southern villages tend to be tomatoes, cabbage, onions, hibiscus, sorrel leaves, and okra. After building fences for protection (protective fences are a major trend in both regions) the soil is prepared and seeds planted. Watering is usually done by hand, but villagers use hoes and *rateaux* (a rake); some use animal traction.

Informants and focus group participants in Asndé Balla, as in other villages, also reported that agriculture does not function as it used to, and that immigration and the sale of livestock is the new trend today. Focus group discussants felt that households relying primarily on agriculture tend to be more vulnerable; for the past eight years, harvests have been slim for both *jeeri* (rain-fed lands) and *walo* (recession agriculture lands). In the past three years, the purchase of livestock feed, as opposed to local grazing, has become more frequent in the villages, as feed is often used to supplement the livestock diet. In both surveyed regions, most villagers believe that this is due primarily to deforestation and a decrease in rainfall. A sack of 40 kilograms of peanut shell, used for animal feed, is sold in the local market for between 75,000 CFA and 100,000 CFA. The purchase of livestock feed may be a new trend in village livestock management, but it primarily benefits wealthier households.

The practice of double cropping, or rain-fed and flood recession cultivation, is now found in some villages such as Ouro Silamaka. The strategy consists of replacing millet and sorghum with corn as a strategy to resist locusts and bird pests. This was a specific strategy for people in villages such as the Cebbo zone in the North (Kiriré, Ouro Cebbo, and Boulone Samba Diadji). Early varieties of *voandzou* (Bambara nut) and taro are now introduced in some areas to cope with climate change and decreasing rainfall in particular.

Adaptive Strategies in Livestock Production

Livestock herds throughout the regions used to be managed by young village men (without pay), but during the past 20 years, villagers have been hiring professional shepherds, a practice that is becoming increasingly costly. Since most households cannot afford shepherds, the option is available to just a few wealthy producers. The need to hire professional shepherds thus limits the mobility of livestock herding as a strategy to protect villagers against drought and other forms of climate change.

Focus group informants in many surveyed villages said that due to the scarcity of rain leading to a decrease in availability of natural animal feed, transhumance is practiced primarily by the wealthy. Poultry stock farming, primarily a women's strategy, is decreasing, and there is more animal disease and a lack of veterinary services to ameliorate them.

In recent years, villagers in both regions have begun to breed more drought-resistant species of cattle, sheep, and goats. Thanks to the increased presence of transhumant herds of larger stock from the North and the investments of youth migrants in the new livestock breeds, herds have grown in size and weight. Crossbreeding with the more drought-adapted northern breeds has been increasing for all large livestock in both regions. The horse breed called *ndama* has been crossbred to form a new mixed breed called *diokooré* (a mix between *ndama* and *gobra*). In Ouro Cebo and Thiewele, for example, the breed of sheep called *diallonké* has been mixed to form the *diokkooré*. This adaptation is successful, as these mixed breeds are more resistant to heat and drought; however, the amount of milk per animal these larger cattle and ruminants produce is reported to have decreased.

Some villagers reported that livestock management is more difficult for the vast majority of households today than ever before. According to key informants in both regions, animal diseases are on the increase (due primarily to the increasingly poor quality of natural feed, with the decline in nutritious herbaceous species specific to strong animal growth and lactation). Villagers tend to link this decline to the decrease in quality of the feed, as vegetation has disappeared due to drought and the increased harvesting of trees for home building given the increase in population. Thus, human activity is a major factor affecting livelihood adaptations, and villagers have no option but to buy *rakkal* (a feed substitute). *Rakkal* is not as dominant in the South, because there is more forest and pasture there; in the South, the poorer people also can have livestock. A bag of *rakkal* costs, on the average, from 9,000 to 10,000 CFA francs.

In both regions, cattle theft continues to be a scourge, and hyenas regularly prey upon livestock. In 2013 in one village, 40 donkeys, 15 cattle, and 13 horses were consumed by hyenas.

In terms of providing income, some village focus group informants reported that farming was the dominant mode of subsistence, but livestock production is now, along with immigration, more lucrative for most village households. The most stable sources of income in the village of Kirere, for example, are selling livestock and immigration.

In the village of Boynguel Bamba, as in many surveyed villages, informants reported that the livestock sector is very promising, especially with the financial contribution of immigrants. Expatriates have acquired new herds, which have strengthened livestock; however, new diseases, bushfires, and lack of pasture hinder the development of animal husbandry. During the rainy season (May – August), diseases decimate small ruminants, especially sheep. During the dry season, the lack of grazing is most harmful to animals, and some animals die. Sale of livestock, however, provides emergency income for medicines, for example, in which villagers can sell off some of their livestock, providing a form of resilience and security for villagers whose gardens experience a lack of water.

Natural Resources and Adaptive Strategies

As noted above, villagers in both regions stated that 20 years ago, nearby forests were denser than they are today and that many plants and trees have disappeared due to village expansion

(increase in population), bush fires, and water scarcity, which people often said is due to deforestation. Villagers in the village of Koar blame transhumant shepherds from Guinea for the increase in bush fires. Villagers believe these shepherds have brought new diseases affecting livestock, so the owners of animals now require private veterinarians. (A vaccine costing 2,000 CFA francs can handle up to 30 heads of small ruminants.)

Gum Arabic is also harvested in both regions and harvested for use as clothing starch.

Villagers reported that these few remaining natural resources are attracting outsiders such as the Baol - baol and Saloum Saloum from other regions of Senegal for picking monkey bread and trafficking in firewood.

While the South is still more densely forested than the North, and while rainfall is more prevalent there, villagers in the South have reported increasing problems and are concerned that the trend in the South is also toward the deforestation, decrease in rainfall, and resource depletion that villagers see in the North. Twenty years ago, the forest surrounding Gambi, a southern village, was overflowing with many species of trees that have now disappeared – especially large trees formerly used for firewood and bamboo. Villagers say the cause is the misuse of forest resources, including logging and bushfires.

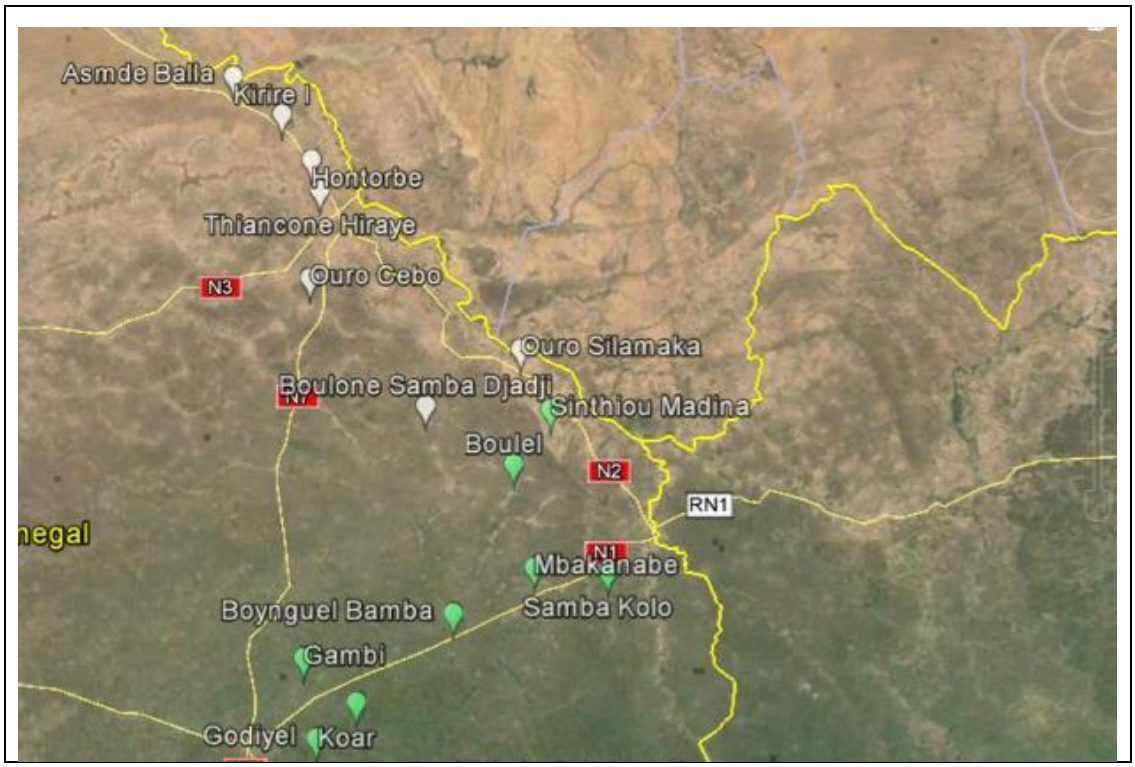
In sum, water scarcity remains the main challenge for the local populations in all surveyed villages. Village lands, animals, and crops are also exposed to cricket attacks, parasites and birds, which villagers said have increased in recent years. Villagers' lives are more vulnerable due to the absence of food during the dry season, forcing them to sell herds to survive.

Immigration as an Adaptive Strategy

Of off-farm activities, immigration is one of the largest sources of village income in both regions. Many young people in the village of Koar, for example, have immigrated to France, Italy, Gabon, and other countries. Some families depend on remittances to meet their basic needs. All young people today aspire to leave the village, but the cost is equivalent to more than 4 million CFA (more than $8,000). Many youth, who used to engage in agriculture and herding, now leave Koar during the dry season to work in painting and masonry in Tambacounda and Dakar.

In recent years, immigration to the West has become increasingly difficult, which has had the effect of reducing the number of people who attempt the journey.

FIGURE 1: MAP OF SURVEYED VILLAGES



Major Differences

This section provides specific data from the surveyed villages that highlight major differences as well as specific and unique details about village livelihood strategies and how these strategies are executed in everyday lives.

In the North

Asndé Balla

TABLE 2: OVERVIEW, ASNDÉ BALLA	
	Asndé Balla has limited access to basic infrastructure such as water, schools, and health facilities, which increases household vulnerability. Households rely on both jeeri and waalo agriculture. This is one of the few sites where land is bought and sold on the market. The village population is very mobile, with a high rate of both migration and transhumance.

Kirere

TABLE 3: OVERVIEW, KIRERE	
	Kirere is located 4 kilometers from the main road. The number of inhabitants of the village during the past 20 years has tripled, with a total of 91 households at the time of this study. There is limited physical and social infrastructure, with no schools or health facilities. Animal traction was introduced in the village in 2002. *Waalo* (recession) agriculture is practiced. There is increased soil infertility. Villagers believe that vegetation has disappeared due to drought and the increased harvesting of trees for home building.

Hontorbé

TABLE 4: OVERVIEW, HONTORBÉ	
	Located in a densely populated zone, Hontorbé is surrounded by other villages. Its population has tripled in the past 20 years. Interviewees say that the State is only present during elections when promises are made. Women claim that an NGO stole 200,000 CFA that had been collected for the extension of their gardens. This case is typical of what villagers call an "NGO *cartable*" ("empty briefcase"): making promises and taking money from villagers under the pretext of helping them organize, then disappearing without paying back the collected funds.

Thiacone Hiraye

TABLE 5: OVERVIEW, THIANCONE HIRAYE	
	Due to climate change, villagers said, village livelihoods are provided for mainly through remittances from expatriates, and to a lesser extent through agricultural income and livestock herding. In essence, the income from agriculture has significantly declined, while the importance of migration has increased. Previously, cows were greater in number in Thiancone Hiraye; however, sheep now predominate.

Herd size has increased, largely due to the contribution of immigrants who engage in herding. Young villagers engage in fattening activities, purchasing a few cattle that are primarily sold before the animals mature.

In what used to be local pastures, many local species of fauna have disappeared. The rainy season promotes sedentary livestock with the availability of leaves and brush, in contrast to the dry season, during which plant species disappear. During the rainy season, livestock can forage closer to home; however, there is more scarcity of natural feed and pasture during the dry season.

Ouro Cebo

TABLE 6: OVERVIEW, OURO CEBO	
	Villagers in Ouro Cebo mainly depend on livestock herding, while agriculture is second in terms of revenue contribution. Villagers said that 20 years ago, the whole family moved with the animals; now, only a few men tend to be the shepherds. Transhumance is greatly reduced. Gardening is now practiced in the village, but production is barely enough for household consumption. Women in the area often harvest Gum Arabic.

Sometimes people may leave the village to serve as professional shepherds in the towns of Ouroussogui and Kanel. Others are *jula* (merchants) or *téfanké* (animal brokers) who work at the large weekly markets in Tambacounda and Matam. Villagers said that 20 years ago, the whole family moved with the animal; now the men tend to go on transhumance.

Ouro Silamakha and Mboulel

TABLE 7: OVERVIEW, OURO SILAMAKHA AND MBOULEL	
	A primary successful adaptive mechanism in Silamakha and Mboulel to the failure of traditional, rain-fed agriculture is the introduction of garden crops that are used both for household consumption and for sale. These are crops grown in the cold, dry season by women (from December to February). Currently, there are two production seasons for growing corn during the same year, in which farmers grow both rain-fed and recession corn.

Informants noted that the majority of villagers have been buying and selling livestock and that compared to 20 years ago, there is more livestock now (mainly sheep and goats). Informants reported that the volume of milk production from livestock has declined in these villages within the past 20 years despite the fact that villagers have more livestock.

Boulogne Samba Dadji and Lordougo

TABLE 8: OVERVIEW, BOULOGNE SAMBA DADJI AND LORDOUGO	
	Livestock farming is the main subsistence activity for the people in this village, but it is important to note that agriculture also occupies an important place in the lives of villagers. There is no school in the village; therefore, children enrolled in school must travel to Ndiote, a village situated 12 kilometers away. For secondary school, children must travel to Dounde, 40 kilometers away. Twenty years ago, *souna* (millet) was the main agricultural product, but it has been replaced by corn and other vegetables such as cabbage, turnip, carrot, eggplant, and squash.

Water access remains problematic, because the three existing wells are not sufficient for household work, consumption, and animal feeding. Many villagers use temporary ponds for water during the winter.

Sheep and goats are the dominant raised livestock. These livestock tend to be taken to Tambacounda and Mauritania for pasture. Most of the school children are girls; however, girls often abandon school early due to lack of financial resources, household work, and early marriage. The village has a French school with six classes.

In the South

Sinthiou Madina

TABLE 9: OVERVIEW, SINTHIOU MADINA	
	The village population has increased from 200 in 1994 to more than 500 people today. Villagers explained this increased by citing the fact that young people are marrying earlier and earlier (15 years for girls and 17 for boys, on average). Migrant remittances are the main source of income for most households in the village.

Economic activity in the village of Medina Sinthiou always has been based on agriculture, which could meet the needs of small families 20 years ago; however, such is no longer the case. Livestock tend to be kept in the village all year.

Boulel

TABLE 10: OVERVIEW, BOULEL	
	Boulel is part of a cluster of hamlets. The population has doubled since the 1990s, from 250 inhabitants to 500 today. During the dry season, village youth visit the Koungheul region, where they conduct small business (for example, shoe shine operations).

Changes in species composition are due mainly to the introduction of cattle coming from Mauritania. These cattle have been interbred with *ndama* cattle. Sheep also have undergone changes due to interbreeding with Mauritanian sheep. The animals used to be bred for cultural reasons, but now they are sold to pay for life cycle ceremonies and for medical expenses. *Téfankés* also trade animals. Today, bushfires have decimated much of the pasture, so animals will graze further away. Many grass species have disappeared due to bushfires and lack of rainfall.

Mbakanabe

TABLE 11: OVERVIEW, MBAKANABE	
	Located near the main road and around 11 kilometers from Goudiry, Mbakanabe is the capital of the department. Access to the village is difficult due to a valley between the village and the highway. The State dug a well in the locality, but it is still difficult to satisfy water needs. The main activities in the village are agriculture and livestock raising.

Farming is, however, becoming less important, villagers say, because the animals are easier to sell and more profitable. Agriculture, on the other hand, is experiencing diminishing returns.

There also are a lot of young people who live in large cities in Senegal such as Kaolack, Mbour, and Dakar during the dry season. There, they work in small businesses (for example shoe shining or street vending). Villagers say that households struggle to ensure daily meals.

Local species include sheep that have been crossbred with sheep from Mauritania. These were traditionally sold only in case of emergency, but now they are regularly sold to meet expenses of life cycle rituals and to pay medical expenses.

Much of off-farm income is also derived from the forestry sector. It used to be that *jujubes* (*Ziziphus mauritania*) and monkey bread (*baobab*) were used only for consumption, but now they are sold on picking. (Villagers can make, for example, 3500 CFA per bag of monkey bread.) It is women who are involved in this trade. For the past decade, Mbakanabe villagers have engaged in trading forest products, including the *baobab* and *Acacia Senegal gum*, as well as the manufacture of bricks and mud beds.

Changes in species composition are mainly due to the introduction of cattle coming from Mauritania, which have been interbred with *ndama* cattle. Sheep also have undergone changes due to interbreeding with Mauritanian sheep. The animals used to be bred for cultural reasons, but now they are sold. Bushfires have decimated much of the pasture, so animals will graze further away.

Samba Kolo

TABLE 12: OVERVIEW, SAMBA KOLO	
	A more wooded area than many of the other villages, in Samba Kolo there is currently little transhumance and more sedentary farming. There is no additional land to cultivate and no fallow; all land is occupied.

Forest products are very useful to villagers here, especially for trade in *baobab* fruits, *jujube*, balanites, and tamarind; all are highly commercialized. According to key informants, animal diseases are increasing due primarily to the increasingly poor quality of natural feed with a decline in nutritious herbaceous species specific to strong animal growth and lactation. Villagers are forced to buy medicines for them. Cattle theft continues to be a scourge, and hyenas prey upon donkeys. In 2013 in this one village, 40 donkeys, 15 cattle, and 13 horses were consumed by hyenas.

Boynguel Bamba

TABLE 13: OVERVIEW, BOYNGUEL BAMBA	
Villagers reported that 20 immigrants in France transfer monthly funds to their families. During the rainy season, local youth will go to Tambacounda, Dakar, or Kédougou to engage in petty trade and to work as laborers. Some youth also go to Kédougou, Mali for gold mining, but they tend to be there for more than two years without returning or sending money due to the difficulties they experience.	

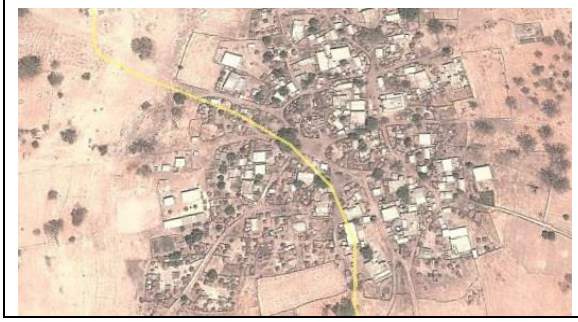
Gambi

TABLE 14: OVERVIEW, GAMBI	
	Farmers have abandoned cotton due to the high cost of inputs from the Society of Textile Fibers (SODEFITEX, now bankrupt due to State withdrawal). Cassava is no longer grown due to reduced rainfall and destructive intrusion of warthogs. Villagers here do not practice transhumance; animals feed close to the village. Herd size has increased due to the increasing importance given to animals as a reliable source of income.

Villagers say that for herds of 60 to 100 heads, they will hire a professional shepherd. This practice is confined to wealthier households.

Most farmers in Gambi do not have access to agricultural equipment and tend to borrow or rent from others, with the exception of animal traction, which villagers say are becoming more common. Vaccination of village animals is made by a private veterinarian for a fee ranging from 1000 to 2000 CFA per vaccine.

Koar

TABLE 15: OVERVIEW, KOAR	
	Local crops such as *sagno, mbayéri,* cassava, and cotton have been abandoned for the same reasons given for Gambi above. There is no transhumance; animals find pasture close to the village. The number of heads of cattle has drastically declined. Of off-farm activities, immigration is the largest source of village income.

Godioyel

TABLE 16: OVERVIEW, GODIOYEL	
Godioyel has no physical infrastructure – no school, health center, or improved wells. The village does not have a school, so, as an informant stated, "no child will study in this village." Livestock is the number-one income generating activity. Pasture is less abundant, and there is an increase of undesirable grasses (*diandiali* and *loubbar*) that are unfit for animal consumption because they are toxic. The population is currently 150 inhabitants, while in 1994 there were only 60 inhabitants.	

Women and Climate Change in the Surveyed Villages

Women are significantly more vulnerable to the impact of climate change due to their important role in providing food and other necessities for their families. In all of the 15 villages, as much as 75 percent of the population tends to be women and children; women are in charge of household and village affairs, while many of the men are away. The women bear the burden of most of the work – childbirth, childcare, hauling water, gardening, livestock care, cooking, cleaning, walking long distances for trade and medical assistance, and so forth. Clearly it is women who bear the consequences of climatic and social change at the local level.

Women noted that they find it more difficult to cope with rising food prices and the increasing demand for food as their families expand, and that village populations have almost doubled in the past 20 years, causing even greater vulnerability. As noted above, migration is prevalent in eastern Senegal, which has particular effects on women. Since migration is a predominately male strategy, many villages are left with women who have to do their traditional share of the work plus the work that the men who left were "supposed to do." A young mother whose husband migrated to France told us, "I am now a woman and a man at the same time." Sadly, while women have become increasing central to livelihood systems in the region, they are significantly more vulnerable, marginalized, and subjected to violence, discrimination, and injustices. Additionally, they have had limited access to resources such as land and credit.

In the surveyed villages, both men and women are involved in securing household income through farming and livestock production. Women in all of the surveyed villages cultivate vegetable crops such as hibiscus, carrots, okra, chili, lettuce, eggplant, tomatoes, and cabbage; some men also cultivate. Women usually own poultry; however, due to increasing heat, they said, villagers are experiencing the onset of a new, so-called "chicken disease" that can completely wipe out household stock. This trend affects mostly women, whose small stocks often disappear overnight. Herding of larger livestock, migration, and farming with animal

traction tend to be predominantly male activities in villages such as Ouro Silamakha, Mboulel, Asnde Ball, and Hontorbe in the North, and Gambi, Koar, and Boynguel Bamba in the South.

Adaptive Strategies and Practices in Response to Climate Change

Households in this study have not been passive bystanders to climate and other forms of change; they have developed a diversified range of strategies to deal with impact, including diversification; innovation; mobility and migration; new technologies; communal pooling; and production for sale, barter, and trade at local markets.

Diversification

Diversification involves investing in productive activities with different sources of risk – for example, planting multiple crops or adding livestock production to a household portfolio. The study found that villagers diversify their opportunities by employing a combination of three major livelihood strategies to make a living. The old model of a primarily farming or pastoral livelihood is no longer viable. In both the North and South, farming households heavily rely on animal production, and some pastoral households also invest more heavily in agriculture, especially in *maraichage*. Migration is the third strategy. Villagers have developed this three-legged livelihood system to ensure livelihoods when one or more systems fail. This adaptation is important in changing climatic conditions and in a rapidly changing and unpredictable social and natural environment.

Innovation

The most significant ways in which farmers from both surveyed regions have adjusted to these climate threats include changes in location of farms (using new types of soils or fields); abandoning or adopting crops or varieties (including vegetables); new practices and technologies; and new markets. The same varieties of crops are cultivated in the North and the South: during the rainy season, millet, okra, peanuts, sorrel leaves, and cowpea; in winter, vegetable crops such as sorrel, carrots, okra, chili, lettuce, eggplant, tomatoes, and cabbage. Irrigation is more developed in the North than in the more forested South, where agriculture has relied primarily on rain-fed agriculture. Water in the South tends to be more poorly managed than in the North, with virtually no water harvesting techniques or technology yet in place.

Changing the varieties of crops has become increasingly common in both regions, particularly drought-resistant and shorter growth cycle, early-maturing varieties at the expense of others. In the past 20 years, for example, millet, which is more drought resistant and requires less water, has become more predominant as a result of local perceptions and experiences of climate change. Watermelon and squash are among the newer crops introduced within the past two decades. These crops adapt well to reduced rainfall and provide high market profitability.

Agricultural practices are also adapting to climate change, both in terms of diversification and intensification:

- The introduction and intensification of new crops systems such as *maraichage,* practiced essentially by women. This trend presents a major new source of household income during the hungry season, especially in the North. By contrast, in the South, irrigation--getting the water from the ground to the fields--is difficult and thus limits the feasibility of *maraichage*.

- The introduction of drought-resistant and early maturing crops, while abandoning others. For example, the *sagno* species (a variety of millet) is no longer cultivated in the village of Boynguel Bamba due to decreased quantity and quality of rainfall.
- The use of animal fertilizers (manure) to compensate for increasingly poor soil nutrients.
- The cultivation of new lands and the reduction of fallow periods. Key informants reported an increase in the area under cultivation (along with increased population); however, the productivity level and long-term health of the soil is decreasing by hectares.
- The abandonment of particular crops. In the South, faced with the resignation and disengagement of the State and its technical units during the past 20 years, farmers have been obliged to abandon cotton production, which used to be a major source of income.

Many villagers reported an excessive reduction in the quantity of harvest due to reductions in rainfall and fallow practices, along with attacks of granivorous birds and predatory insects. Numerous changes have transpired as a result. For example, in the northern villages of Silamakha and Mboulel (as in much of the North) the number-one crop is the *sunna* variety of millet, which used to be the villages' third-most important crop. Some villagers perceive climate change to have directly caused this change, experienced locally as a lack of rain and grain-eating birds and insect predators that prefer sorghum to *sunna*. More than 20 years ago, sorghum was the first major crop that was cultivated; however, sorghum has come to rank variously second or third, depending on the site. Local varieties of sorghum have been abandoned due to scarcity of rains and inadaptability to current weather conditions, as these crop varieties require a lot of water and nutrient rich soil. Villagers additionally noted that sorghum is extremely vulnerable to invasions of insect and birds.

Corn, one of the three most important crops in the area, is now cultivated in two modes, rain-fed and recession. Traditionally, corn was grown only in rain-fed mode; now, it is grown also in recession mode when temporary ponds dry out. One reason community interviewees provided is that the variety of newly cultivated corn is more resistant to attacks from birds and insect predators. It also has a shorter growing season and requires less water. Okra has become more intensively cultivated because of its cash crop potential.

In the same way that agriculture is diversified, livestock management is also adapting to climate change through diversification and intensification. Focus group informants in both regions reported that crossbreeding of transhumant livestock with traditionally sedentary livestock has led to a new, improved, and more robust stock that is better adapted to changing climatic conditions. Unfortunately this new variety produces significantly less milk.

In the formerly densely forested South, there is a more pronounced awareness of the need to preserve the natural environment — trees, forest, wildlife, and water — as a result of the perceived impacts of climate change and deforestation. Because more land is being put under cultivation in the South to compensate for low productivity, people report a decrease in biomass, which ultimately affects livestock feed and the overall health of the ecosystem. Despite their limited means, villagers are organizing in attempts to salvage what is left of the forest ecosystem and to protect it from further resource depletion.

Farmers perceived the loss of pasture and feed due to agricultural expansion and deforestation also to be caused by climate change, and particularly by rainfall instability. In the North, transhumance usually has been practiced in the Tambacounda and the Ranérou areas during the dry season; in the rainy season, the animals would remain in home villages (such as Silamakha, Mboulel and Asnde Balla). People reported that during the past 10 years, the time that the animals remain in the home village has decreased due to the scarcity of pasture and feed.

As noted above, in the formerly heavily forested South, there is almost no transhumance even during the dry season, unlike in the North, which relies heavily on moving livestock the long distance to Mali and returning only when good pasture again becomes available in their home villages. During the past 10 years, the time that the animals remain in the home village has decreased due to scarcity of pasture and feed. Despite the relative abundance of pasture in the South, within the past two decades the arrival of large herds of animals originating from outside the region has led to severe overgrazing that, when combined with the perceived effects climate change, has resulted in pronounced depletion of land and water resources in this region.

In the North, the destruction of forests and grassy pastures has led to an increase in transhumant herding. The study noted that the international diaspora communities of migrants have tended to invest more money in livestock since out-migrating. This outside influence has contributed to the commoditization of livestock locally, such that livestock is no longer tied to traditional forms of prestige and lacks sentimental value. Key informants say that livestock in eastern Senegal has become a commodity tied primarily to monetary profit, and that with the introduction of new animal species, livestock interbreeding fares better at regional markets. (This trend is also seen in the increase in the number of livestock at weekly markets.). Due to a greater market orientation in the North, we see larger numbers and more robust reproducing of species of livestock due to increased commercialization, commodification, and intensification of livestock production. As these cattle do not produce ample milk, recently emphasis has been placed on meat production more so than on milk production.

In the South, the trespassing and overgrazing of transhumant herders coming in from the North in search of pastures during the dry season has become a major source of conflict. Communities of the South also claim that the newly introduced species of livestock from the North contribute to new animal diseases that were unknown to them in the past.

Livestock management in both surveyed regions has drastically changed its face. While young people who used to be involved in agriculture also managed their parents' livestock, most recently, due to low agricultural production, villagers noted an increase in the number of young people migrating to the larger urban centers, obliging their parents to recruit *bergers* (professional shepherds) who tend to be from the north to care for their herds. Villagers feel that they have no choice and they do not always trust the *bergers*, who they sometimes accuse of stealing livestock.

Another major change in both regions is that livestock ownership is becoming more generalized. In the past, a few households owned lots of animals; now, a greater number of households own at least a small number of livestock. As a result, livestock distribution has become somewhat more equitable. However, only wealthy households can afford long-term

transhumance, because it is very costly (herds are often moved greater distances to resource-rich regions – southward and then to Mali).

Informants noted that previously, crop residues were used to feed livestock (cattle in particular). Crop residues were transported in carts or by donkey, or carried on women's heads. But today, due to shorter rainy seasons, the quality of crops has declined, and households are forced to buy supplemental feed for livestock. This trend might explain, in part, why households have fewer cattle than they did 20 years ago. The study also notes a greater reliance on supplemental feeding, called "*rakkal,"* which must be purchased in the market (even though a portion of *rakkal* is theoretically intended to be freely distributed, rather than sold). People who own livestock and do not practice transhumance are very often obliged to rely upon *rakkal* for supplemental feeding for livestock.

A large number — 100 or more — of large livestock are owned by the wealthier households, both newly rich immigrants as well as hereditary classes of village chiefs, and so forth. In the above section on livestock production, the study findings detail some of the reasons that there is a greater divergence between rich and poor, which informants perceive as being partly due to immigration.

In both the North and the South, there has been a great increase in the numbers of small ruminants — sheep and goats — as compared to the number of cattle. This trend is viewed as a recent adaptation to climate change. Villagers say that sheep and goats are easier to raise in climates with variable or scant rainfall.

Climate change also has negative effects on poultry, particularly chickens. This issue was repeatedly noted in women's focus groups. Increasing heat has had a drastic effect on the chickens, including the onset of a new, so-called "chicken disease" that can wipe out household stock in just a few days. This trend mostly affects women, whose small stocks disappear overnight.

Mobility and Migration

Migration and mobility is one of the major adaptive practices developed in response to the effects of climate variability in the two regions of this study. Migration and mobility variously refer to shifting the location of productive assets, whether family, labor, or herds.

Focus group informants mentioned three major forms of migration: seasonal, long-term, and permanent. Seasonal migration is a function of the amount of rainfall and the quality of the rainy season, including the timing of onset, consistency and spread of the rain, and the degree of insect and bird infestation. During a good season, people tend to stay longer in their home communities; however, when conditions worsen, they tend to leave early and stay away longer.

Long-term and permanent migrations to France and other European and African countries are adaptive strategies that have to do with securing remittances from abroad to supplement income. In most of the surveyed villages, these remittances constitute the dominant form of cash income.

In the North, persistent droughts have led to a high rate of migration to West African urban centers and to Europe and the United States. What used to be a coping strategy has become a major factor in the development of the North in contrast to the South, where migration is less

pronounced due to less severe drought conditions. But in the past 10 years, long-term and permanent migration, more common in the North, have become increasingly difficult due to stricter immigration laws in the West; thus, there is a trend toward migrating to urban locations, where villagers seek non-farm employment. Informants noted that in the past 10 years, financial remittances from migrants to their home communities have significantly diminished. For example in the villages of Silamakha and Mboulel, the main source of cash income is remittances because of poor soil quality and other unfavorable conditions.

New Technologies

Overall, in both regions agricultural yields have significantly decreased, which limits the proportion of income coming from the agricultural sector. One of the major changes in adaptive strategies in agriculture is the introduction of new tools to cultivate the fields using new technologies often introduced by migrants and/or funded by migrants, such as plows and seeders. However, the major innovation is animal traction to haul tools and machines such as plows and seeders. Before, people used the more labor-intensive hoe, the *daba,* or the *hilaire.* Animal traction was introduced by Saloum Saloum in approximately 2002. Due to the innovation of animal traction, more land has been put under cultivation, and there is a reduced need for manual labor.

A negative adaptation, in which farmers have little choice, has been the reduction of the fallow period in lieu of the need to increase land holdings as a means of increasing production and profit. The adaptation of new technologies is a way to compensate for decreasing the fallow period.

Communal Pooling of Resources

Beyond the household level, lineages and whole villages still tend to pool resources — for example, pooling labor in household gardens, managing livestock, distributing remittances from immigrants, and so forth — particularly in times of need and scarcity. A key trend village informants noted is that the traditional system of pooling community resources has declined. For example, village elders in Gambi, Boulel, and Godiyel complained that the young people were not fulfilling their traditional contributions in providing free labor to households in need and were increasingly asking to be paid for their labor. Despite their limited means, villagers are organizing at the village level to salvage what is left of the forest ecosystem and to protect it from further resource depletion.

Markets

Weekly markets play an important role for households in the survey areas, especially for the women. When women need access to income for clothing, food, or miscellaneous household items, this meeting place is crucial for trade and barter. Women travel long distances and exchange important information that helps to reduce vulnerability. Given the importance of livestock, especially sheep and goats, the market is a place where livestock can be transferred into cash to be used for other purposes. Market exchange is becoming a reliable source of asset accumulation and a space for the exchange of diverse goods in times of need (adapted from Agrawal, 2011).

An interesting finding producers revealed is the special relationship that has developed between traders or merchants and agricultural or livestock producers, in which traders and merchants pre-finance producers – for example in Asnde Balla during harvest, or in Ouro Cebo for livestock production. By borrowing money from merchants, the merchants get special treatment from producers – preferential prices at the time of production or harvest. Despite the appearances of increasing financial security for the producers and potential insurance in times of need, this practice creates a patron-client dependency that ultimately favors the patron, as it potentially limits the profits of the clients and their ability to compete in a free market.

Major Constraints and Community Preparedness

Key informants and focus group discussants identified major agricultural constraints including, most importantly, lack of water; unpredictable weather patterns; the decline in soil fertility; low inputs of fertilizers and seeds; obsolete agricultural equipment; and the invasion of insects, pests, and birds. According to village informants, low rainfall has caused a significant decline in the production of traditional crops, mainly millet and sorghum, and has contributed greatly to villagers' food insecurity.

Major constraints in the livestock sector primarily include access to water and access to animal feed. Other constraints include disease outbreaks, livestock theft, the decline in pasture land along with the decline in traditional highly nutritious and natural animal feed, and the increased frequency of animal diseases (which villagers view as being due to persistent drought and the influx of foreign stock). As is the case in agriculture, these constraints result in poverty and a lack of livelihood security. Most of the surveyed communities believed that they do not have capacity to prevent and manage big crises or disasters that can affect their livelihood. With recurrent outbreaks of food crises in both the North and the South, communities found it necessary to create emergency stocks to respond to crisis situations.

Focus group informants frequently mentioned conflict management between herders and agriculturalists, between villagers, and between villagers and "outsiders" as an important element of the development process. Informants pointed out that unless the root causes of conflict are addressed, these conflicts (especially between herders and agriculturalists) can increase communities' vulnerability, expose them to risk, and undermine other development achievements. They stressed the need, for example, to strengthen local communities' ability to anticipate and manage conflict by strengthening the role of the traditional chiefs in conflict resolution through special training to help them better understand the law and their role in conflict management. There seems to be an urgent need to build local capacity for monitoring, warning, and responding to risks and conflicts that threaten livelihood systems.

Community Views on Outside Interventions

From the perspective of both men and women interviewed, the communities have had little contact with development institutions. Neither the State nor NGOs have had little, if any, presence in the 15 surveyed villages. The research team noted that villagers were very happy that a team came and spent time listening to their issues, even if no promises were made.

There seems to be a major disconnect between the discourse on climate change and official, planned actions on the one hand, and what the research team discovered was happening on the ground on the other. There is a lack of coordination and communication between institutions — local and international — that work on climate change in the region. At the rural community level (CR), resources and information sharing are extremely limited. A young woman in one group noted that many of the so-called development institutions are "empty barrels making a lot of noise with few concrete actions."

The USAID-financed Yaajeende Project was mentioned in a few communities, but people said they primarily focused on agriculture, which seems to be concentrated in the South. Communities expressed the concern that the project was not dealing with one of the dominant production systems in the area: livestock. Another initiative they mentioned was La Lumiere, a local partner of Oxfam America that works with women's microfinance groups in the South (Tambacounda Region). Savings groups present a platform for opening discussion on the impact of climate change on women's income-generating activities.

In all of the focus group discussions, informants pointed out that the combination of declining agricultural investment, cyclic drought, floods, and rapid population growth has increased pressure on arable land. Despite numerous discussions on the negative impacts of climate change, they also noted that only a few development programs have aimed at providing food security and environmental protection in the study area. These programs have included agricultural intensification projects, irrigation, tree planting, and soil and water conservation programs. However, according to the focus group discussions, less impact than expected has been achieved, and crises persist with much more acuity.

CONCLUSION

In one of the poorest and least food-secure areas in Senegal and in the context of discussions on the negative effects of climate change, informants consistently complained about the lack of reliability and profitability of agriculture as compared to 20 years ago. Villagers consistently linked this shift to climate change – the unpredictability of rainfall, the reduced duration of the rainy season, the increased temperatures, the decreased productivity of the soil, the increase in bush fires and bird and insect predators, and the trespassing of animals into the fields.

While all of the villages surveyed in both the North and the South currently engage in livestock production, climate change presents major challenges in this area, too. For example, focus group discussants stated that when there is too much rain during the rainy season, sheep are at risk of death; they explained that sheep survive better in the dry North. Women in particular noted the effects of climate change on poultry, specifically chickens. Women's focus groups repeatedly noted that "increasing heat has had a drastic effect on chickens, including the onset of a new chicken disease."

Water was the most important concern that focus group interviewees expressed. Scarcity of water and water management systems constitutes the most limiting factor in all adaptive strategies in both farming and livestock production. Water in the South tends to be more poorly managed than in the North, with virtually no water harvesting techniques or technology yet in place. The study strongly recommends meaningful initiatives to increase the accessibility

of village and household water. In the South, for example, water-harvesting techniques need to be developed to prevent or reduce water run-off.

In response to these changes, the surveyed villages indicate a practiced resilience and adaptability to changing climatic and global conditions. One finding of the study is how villagers diversify their opportunities by employing a combination of basically three (rather than the formerly one or two) widespread livelihood strategies to make a living. In the same way that agriculture is becoming more generalized to both regions and more diversified and intensified, livestock management is also adapting to climate change through diversification and intensification as seen, for example, in the crossbreeding of transhumant livestock with traditionally sedentary livestock. This practice has led to a new, improved, and more robust stock that is better-adapted to changing climatic conditions; however, it is a double-edged sword, because this new variety produces significantly less milk for household consumption.

Villager informants noted that without migration as an adaptive strategy, livestock production would be a much less secure investment in the event of droughts such as those of the 1970s and 1980s. Key informants and focus discussion interviewees revealed that migration serves to increase resilience, because they use foreign remittances to rebuild herds. According to villagers, the rebuilding of herds after drought — often beginning with sheep and goats, which reproduce quickly — would be virtually impossible without these funds. This situation represents a change from the conditions reported by Santoir and other authors who noted that herders were hit hardest by the severe droughts of 30 and 40 years ago because, unlike a farmer's land, their capital was totally decimated. The subsequent rise in migration has substantially increased herder resilience as part of the three-legged strategy of agriculture, livestock production, and migration.

One important trend that should be noted for both regions is that as livestock becomes more capital intensive, there seems to be greater wealth concentration in livestock production, creating a greater divergence between rich and poor. This process is fueled by immigration, which brings with it both monetary funds (with remittances primarily going into livestock) and technological inputs such as animal traction and new plows and seeders. Only the wealthier households can afford veterinary services and *rakkal* (a commercial feed), which villagers say have become increasingly necessary. Many of these wealthier households receive remittances from long-term and permanent migrants, primarily young men.

An important producer finding that brings together villagers' changing adaptations to climate change and globalization is the special relationship that has developed between traders, or merchants, and producers, in which traders and merchants pre-finance producers for agricultural or livestock production in return for preferential prices at the time of production or harvest. This practice effectively limits the potential profits of the producers and their ability to compete in a free market. One recommendation would be to make credit available to producers so that when they need inputs for production, they do not have to rely upon traders and merchants; in other words, there is a need to create decentralized and accessible credit systems at the local level.

Villagers pointed out that in spite of their villages' poverty and food insecurity, there have been only a few development programs that have helped provide food security, infrastructural support, or environmental protection in the study area. Clearly, development agencies at the

local, national, and international levels need to actively support a vision that puts people's experiences of climate change on the ground at the center of discussions of climate change policy and recommendations.

It is important to note that the study found that climate change is only one key driver underlying the current socio-economic conditions of the surveyed communities. Globalization, with its attendant market vulnerabilities, population pressure, potential situations of conflict between herders and farmers (and encroachment of foreign herders with large-scale livestock commercialization) presents its own set of challenges and consequent change, as what has worked well in the past may not work in the future. On the global level, climate change contributes to this unpredictability. In the face of climatic threats, documenting successful adaptive practices — such as the cultivation of millet, the introduction of animal traction and intensification of *maraichage* during the past 20 years, as well as shifting livestock management techniques — is a critical component of the study of resilience and adaptation in the face of global climate change.

The study also has concluded that a major component of this adaptive vision needs to be the inclusion of women as change agents in the fight to attenuate the negative impacts of climate change. As the woman is often the foundation of family and community, she must be considered a key player whose opinion is valued; she must be listened to in the identification of community needs in community and household adjustment to climate change. Women need to be empowered locally, because while women have become increasingly central to livelihood systems in the region, they remain significantly more vulnerable; marginalized; and subjected to violence, discrimination, and injustices; they also have limited access to resources such as land and credit.

Most of the surveyed community members believe that villagers who are poor and vulnerable will likely experience increasingly severe shocks and stresses related to climate change in the future. In their view, only God can reverse this trend. It would be naive for the researchers to assume that we can develop the capacity of local communities to independently cope with and/or recover from future climate change impacts. External intervention will likely remain critical, no matter how strong local risk reduction and adaptation efforts are. Developing the capacity of relevant national and local-level institutions to provide support must, therefore, be an integral part of building resilience to climate change. We cannot emphasize enough how important it is that policy and ameliorative measures be grounded in villagers' everyday experiences of climate change as they attempt to sustain themselves.

Two sites were initially chosen for this study, but physical inaccessibility to the sites prohibited survey activities. When the sites do become accessible, in March or April 2014, it would be beneficial to the study to obtain comparative data from these remote villages. This effort will provide useful insights for understanding adaptation to climate change in some of the more remote villages in the region.

Finally, the study points to the need to preserve and protect the few remaining forests in the South from large-scale overgrazing, wildfires, both private and commercial logging, and the depletion of land and water resources from other changes that villagers say are beyond their control.

Even in years with acceptable rainfall, domestic food production provided only a fraction of villagers' food needs, due primarily to limited arable land in the North and traditional low-yield production systems in both regions. Households have traditionally coped with food shortages by relying on cash earned from the sale of livestock as well as livestock products and remittances from family members living abroad. But a series of shocks since the early 1970s has eroded villagers' assets. In both areas, high malnutrition levels are directly linked to increased food insecurity and a fragile environment. Informants consistently noted that this structural food insecurity results from severe and precarious climatic conditions reflected in low agricultural soil fertility, low agricultural productivity, and the degradation and diminishing of natural resources (water, vegetation, and food sources). The impact of the food situation, people said, is reflected particularly in the health of the population, household nutrition, and access to potable water and to energy.

ANNEX T. CLIMATIC CONDITIONS IN THE SOUTHEAST OF SENEGAL PROJECTED AT THE 2030 AND 2050 HORIZONS

This annex presents the methodology and main results of projections of future climate characteristics in southeastern Senegal. Annual and monthly values for rainfall and temperature projected for 2030 and 2050 are derived for five stations within and around the region of interest for which observed data could be accessed. Large-scale projections from the latest Coupled Model Intercomparison Project Phase 5 (CMIP5) (CMIP5) are customized to the local conditions and put in the context of past long-term variations in climate of the region. The spread among the projections from different models is assessed and captured in the conclusions. Monthly projected values from three models projecting the wettest, driest, and average changes in climate are extracted for further impact studies of those conditions on crops, biomass, and livestock, performed by the Senegalese Agricultural Research Institute (ISRA) and the Centre for Environmental Monitoring (CSE) and presented in Annexes Q and O.

The current annex briefly describes the projections – sources and models – and the statistical method to derive localized projections, then presents rainfall and temperature values for 2030 and 2050 as well as the anomalies with respect to current climate. It then compares them to the conditions that prevailed in the 1971–1990 period, during which the general dry conditions had significant impacts on food security as well as agricultural and pastoral production in the Sahel. During that period, the dry conditions also led to profound societal changes.

1.0 PROJECTION METHODOLOGY

1.1 Rationale for downscaling and bias-correction

Future climate conditions are estimated using General Circulation Models (GCMs), which are state of the art numerical representations of physical and chemical processes within the climate system. Such models allow one to modify atmospheric composition to account for the release of greenhouse gases into the atmosphere and estimate the effects of such changes on atmospheric and oceanic circulations, temperature, and rainfall. Those models represent the processes in the climatic system to the best of our current knowledge and technological capacity; however, they remain an imperfect representation of the system and better capture general characteristics of large climatic systems, such as monsoon systems, than climate conditions in a given location. In particular, it is well established that the representation of the West African Monsoons – the main system driving the climate in West Africa – captures reasonably well its northward shift between May and October and its southward retreat from November to April; however, the exact amplitude and timing of this shift, as well as the exact amounts of produced rainfall, can be over- or under-estimated (Xue et al., 2010). This inexactness is partly due to a relatively coarse resolution of the models that cannot capture many local features such as water bodies, mountain ranges, and changes in land cover. In the particular case of the West African monsoon, GCMs have difficulty in accurately simulating exchanges between land-surface and atmosphere, such as exchanges of moisture and heat that drive the monsoon. Coupled ocean-atmosphere GCMs, such as those used in projections, also do not represent all the modes of oceanic variability important for the West African Monsoon (Joly et al., 2007).

Therefore, it is usually recommended that one correct such systematic biases a posteriori either by 1) using 'regional models' that only cover small parts of the globe and have a higher

resolution that allows one to capture many local features; or 2) by statistically adjusting rainfall amounts, average temperature, and other climate variables based on local observations. The latter method is very flexible and allows one to 'downscale' changes in large-scale climate that the GCMs produce to any resolution/location; however, regional models remain limited to a resolutions above 10 km x 10 km and carry some of the GCMs' systematic biases. In this study, we chose to use a statistical downscaling method to project changes in climate for the five locations where climatic data are available – Tambacounda, Goudiry, Bakel, Matam, and Podor.

In addition to downscaling, the analysis involved assessing uncertainty in the projections by considering outputs from several models with distinct characteristics and systematic biases, as well as the amplitude of future variability.

Details on the data and methods used are presented below.

1.1.1 Data and methods

- Observed monthly values of rainfall, Tmin and Tmax, relative humidity, and wind-speed were obtained for five stations (Tambacounda, Goudiry, Bakel, Matam, and Podor) courtesy of ISRA. Data in most stations, especially rainfall and temperature, cover the full 1970–2010 period; there are shorter records for wind speed.
- GCM outputs at nominal resolution between 100 km x 100 km and 300 km x 300 km were obtained from the CMIP5 – the official archive of the last Intergovernmental Panel on Climate Change (IPCC) assessment. Data from 10 different models under two emission scenarios – RCP4.5 (corresponding to current levels of emission) and RCP8.5 (corresponding to increased emissions) were retrieved. Table 1 summarizes the used models. Projections of precipitation, temperature, relative humidity, and wind were retrieved for the 2020–2060 period, which was further split into two 20-year periods (2020–2040 and 2040–2060) to respectively document the climate of the 2030s and 2050s and its variability. Twenty-year periods were chosen to match the periods used in the analysis of observed climate. In addition to projected values, values for the historical 1971–2005 period were also obtained and used in the bias correction/downscaling scheme.

TABLE 1: GCMS USED TO DERIVE PROJECTIONS, INCLUDING COUNTRY AND INSTITUTION THAT DEVELOPED THE MODEL AS WELL AS MODEL RESOLUTION

Model	CanESM2	CCSM4	CNRM-CM5	CSIRO-Mk3-6-0	GISS-E2-R	HadGEM2-ES	MIROC-ESM	MIROC5	MPI-ESM-LR	MRI-CGCM3
Country of origin and Lab	Canada CCCMA	USA NCAR	France CNRM-CERFACS	Australia CSIRO-QCCCE	USA NASA GISS	UK MOHC	Japan MIROC	Japan MIROC	Germany MPI	Japan MRI
Res. lat x lon	2.8x2.8	0.9x1.25	1.4x1.4	1.87x1.87	2x2.3	1.25x1.87	2.81x2.81	1.4x1.4	1.8x1.8	1.125x1.125

Note: At the equator, 1 degree latitude or longitude corresponds to 110 km.

- The raw outputs were then statistically downscaled focusing on correcting biases in the timing of the season; the magnitude of rainfall, temperature, and other variables; and the

amplitude of their interannual variability (which the models tend to underestimate). To achieve this, a multistep downscaling procedure was applied using monthly records of rainfall, Tmin, Tmax, relative humidity, and wind speed observed in the five stations, as discussed below.

a) For each station and each model, a grid point was identified where the seasonal cycle of rainfall matches best the average observed seasonal cycle.

b) Linear regressions between monthly rainfall values observed and simulated in matching grid points during the historical period were then computed for each calendar month (January to December) using ranked values.4 Those regression equations were then used to predict bias-corrected values of projections, with raw projections used as predictor. In other words, GCM projections of rainfall, temperature, etc. are used as predictors to derive more realistic values based on predictive relationships established using observations and simulations of the historical climate. The bias-corrected historical average seasonal cycle using those regressions perfectly matches the average observed seasonal cycle (not shown). Thus, the results presented below, in addition to the values used in simulations of climate change on crops, biomass, and livestock (Annexes I and O) use the projected values for rainfall and temperature that were corrected following the procedure above.

c) However, statistical tests evaluating the significance of changes in the 20-year means (Student's t-test) and variability (Fisher-Snedecor F-test) with respect to 1985-2005 historical simulations were computed for each model on the raw, uncorrected values.

- CSE used models to document impacts of current and future climate variations on biomass, surface-water resources, and livestock that require rainfall and temperature at a daily time step. Raw daily model outputs are deemed unreliable and suffer from even more systematic biases than do monthly and annual averages. Thus, projections of daily values require further temporal disaggregation, which is particularly difficult in the case of rainfall because it is not uniformly distributed throughout the season. In addition, in the Sahel, rainy events tend to cluster in multi-day wet sequences separated by dry sequences of various lengths. Predicting a correct sequence of wet and dry spells as well as the values of daily rainfall remains particularly challenging and requires specific tools. Daily temperature, on the other hand, varies less and generally follows the average seasonal cycle; therefore, it is easier to predict.

  a) Daily rainfall sequences corresponding to various projected seasonal cycles were derived using the LARS-WG stochastic weather generator – a tool specifically designed for temporal disaggregation of rainfall. LARS-WG is characterized by its ability to derive daily sequences based on statistical characteristics of rainfall observed in the given

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4 GCMs are not expected to reproduce the exact historical time-series of rainfall, temperature, and other variables observed in a given location; only statistical characteristics such as average monthly rainfall and its standard deviation are expected to coincide with the observations. Thus, regression models cannot be constructed by associating observed and simulated values in time. The team chose here to construct the relationships on values that were ranked from smallest to greatest in the historical and simulated series; in that way, bias in the amplitude of variability can also be corrected.

location without pre-supposing the shape of the distributions. In this case, more than 30 years of daily rainfall data were available to train the model and define rainfall distributions. LARS-WG also has the capability to derive daily temperature values consistent with rainy events; however, in this case, no daily temperature data were available to train the model.

b) Daily temperature data were obtained using a less sophisticated approach: interpolating between the monthly values and adding a small random element consistent with the standard deviation of temperature for a given day, derived from publicly available daily temperature records in the region.

- Presented results show changes in 20-year average rainfall, Tmin, and Tmax for the 2020-2040 and 2040-2060 periods for 10 models and the multimodel ensemble. To provide context, 20-year averages of observed values for the 1971-1990 and 1991-2010 periods are also shown in the same figures. Statistically significant changes in average values and variability projected by the multimodel ensemble are additionally highlighted.

- To further assess the range of projected changes and provide inputs for an evaluation of impacts of potential climate change on crops, biomass, and livestock, three models were selected for each time horizon and each emission: a dry model (second to the model simulating the driest conditions over the region), a wet model (second to the model simulating the wettest conditions over the region), and a 'normal model' (closest to the multimodel ensemble average). For each of the selected models, driest, normal, and wettest years were then determined for the two future 2020-2040 and 2040-2050 periods; monthly values of rainfall, Tmin, Tmax, relative humidity, and wind speed made available to ISRA and CSE for impact modeling. Table 2 presents the models selected for each period.

TABLE 2: GCMS SELECTED AS WET, NORMAL, AND DRY MODELS

	Selected wet normal and dry models			
	RCP4.5 2030	**RCP4.5 2050**	**RCP8.5 2030**	**RCP8.5 2050**
Wet model	MIROC-ESM	MIROC-ESM	MIROC-ESM	MIROC-ESM
Normal model	MRI-CGCM3	MRI-CGCM3	CNRM-CERFACS	CNRM-CERFACS
Dry model	MPI-ESM-LR	CSIRO-Mk3-6-0	MIROC5	CSIRO-Mk3-6-0

Note: on average, these GCMs generate wettest, normal, and driest conditions over the study area under different emission scenarios and for the two future time periods.

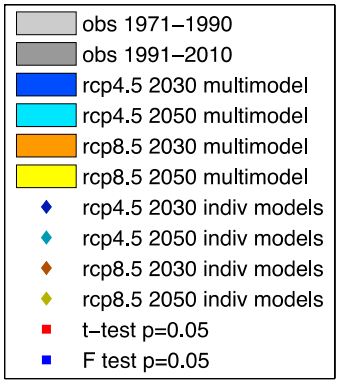
2.0 MAIN RESULTS

The subsequent figures summarize the changes in rainfall, Tmin, and Tmax projected by all 10 models, downscaled/bias-corrected for the five stations. A homogenous representation has been adopted for all the variables and stations; each figure presents the average seasonal cycle (i.e., monthly values averaged over 20 years) on the top panel for the two observed periods (in grey) and projections (in colors). In addition, the standard deviation computed over the 20-year period is plotted for the observations in order to provide context. For the projections,

multimodel estimates are presented in bars, and the results of each individual model are plotted as dots of the same color to allow an easy estimation of spread among the models. The key in Figure 1 provides further details.

The bottom panel presents the same results as anomalies with respect to the 1991–2010 average in order to better assess the amplitude of changes. In the case of rainfall, the anomalies focus on the wet season, May to October; for temperature, the full seasonal cycle is presented.

FIGURE 1: KEY FOR THE FIGURES SHOWING PROJECTED CHANGES IN CLIMATE (RAINFALL,



TMAX, AND TMIN) FOR THE FIVE STATIONS

3.0 MAIN CONCLUSIONS

3.1 Rainfall

Multimodel ensemble average, bias-corrected projections show a potential tendency of lower-than-current rainfall of the same order of magnitude or lower than the conditions observed in the 1970s to early 1990s. For the months in which the changes are strong and well defined, after bias-correction most of the models simulate anomalies of the same sign. Interestingly, the anomalies follow the seasonal cycle of the anomalies from the 1970s; in the southern stations, the early part of the rainy season (June–July in Tambacounda, July in Goudiry) is wetter than the current average, but the remaining portion of the season is drier. In the northern stations of Matam and Podor, all months are drier, as during the early historical period.

3.2 Temperature

The overall picture is one of a very strong warming in all stations and all months. Tmax and Tmin are projected to increase from 2 °C to over 5 °C in certain months in the 2050s under RCP8.5. This strong temperature increase is consistent with regional projections, but here again one can more precisely document the amplitude and seasonality of those changes. Tmax is projected to increase the most during current colder phases of the year (December–February and June–September), flattening the seasonal cycle. However the increase in temperature during the hottest months of the year brings Tmax to approach or even cross a 45 °C monthly average in most of the stations. Tmin, on the other hand, may increase the most

during the coldest months of the year (December–February) and the least during the rainy season.

The wettest models that project an increase in precipitation also project the smallest increase in Tmin and Tmax (~2–3 °C) and are relatively similar among the scenarios and horizons. In turn, the driest models project changes exceeding 5 °C in some cases; however, the differences between wettest and driest models are less marked for Tmin than for Tmax.

It is worth noting that during the past dry period of the 1970s to the early 1990s, in general climate was colder by 1-1.5 °C than during the 1991–2010 reference period. Thus, while projected rainfall patterns point to the conditions from the past, the overall climate certainly will be different due to temperature increase. Southeastern Senegal may face a reduction in rainfall and an increase in temperature, or a small increase in rainfall and an increase in temperature. In both cases, due to increased temperature, the evapotranspirative demand on plants may change the current water satisfaction ratios for numerous crops and rangelands as well as lead to faster depletion of surface-water resources.

4.0 MULTIMODEL RESULTS FOR RAINFALL

FIGURE 2: PROJECTED MONTHLY RAINFALL (TOP) AND ANOMALIES (BOTTOM) FOR THE TAMBACOUNDA STATION

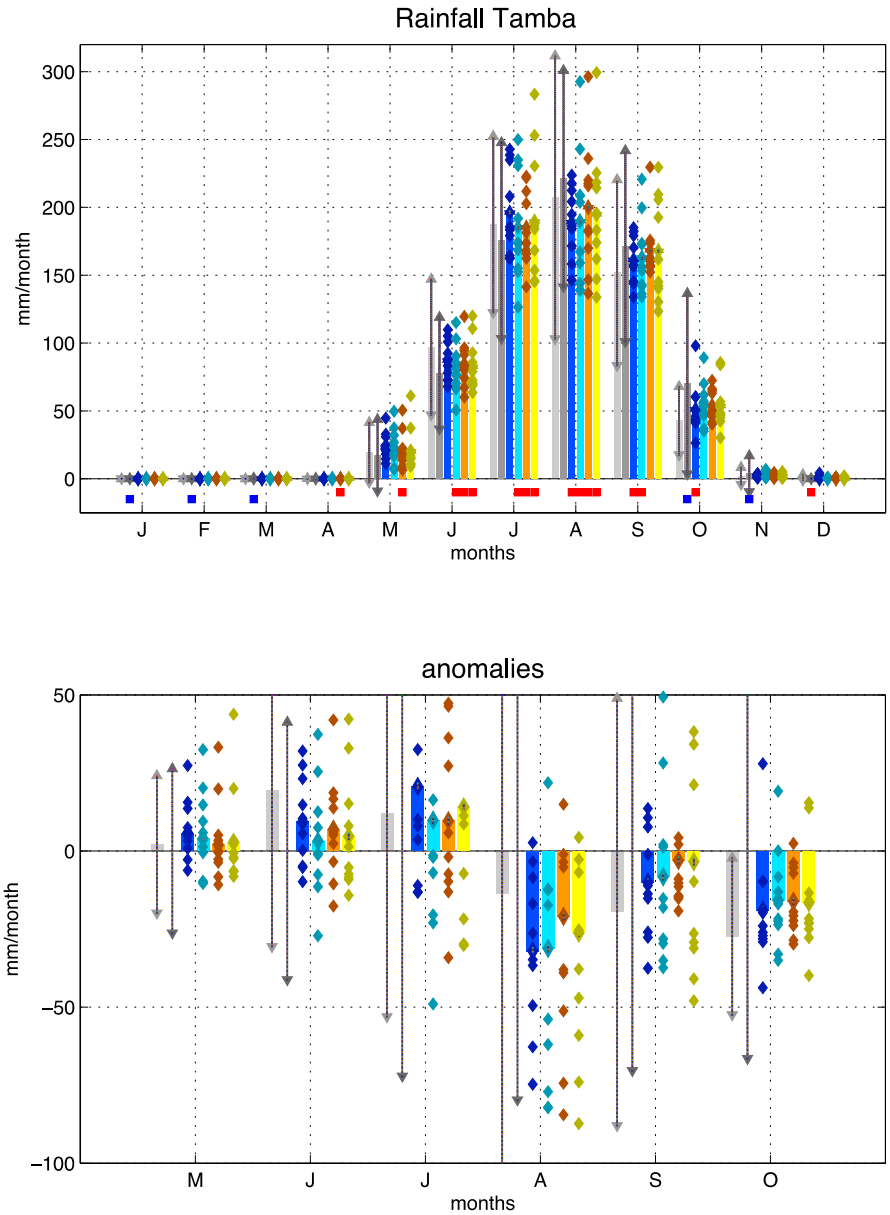
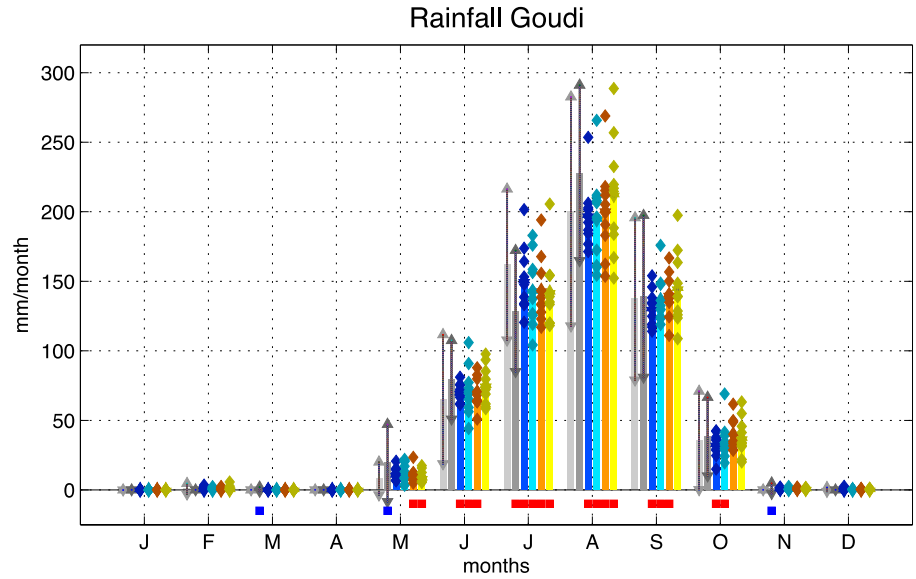


FIGURE 3: PROJECTED MONTHLY RAINFALL (TOP) AND ANOMALIES (BOTTOM) FOR THE GOUDIRY STATION



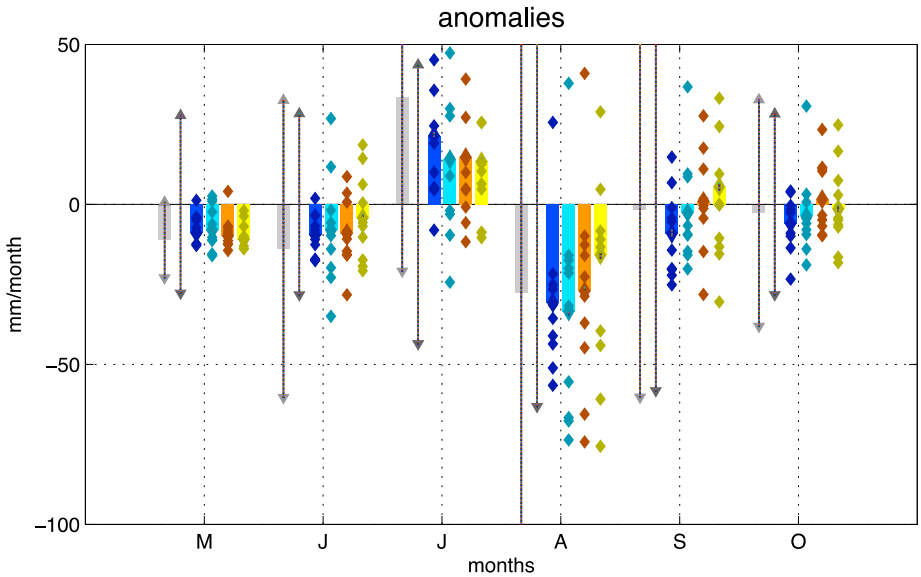
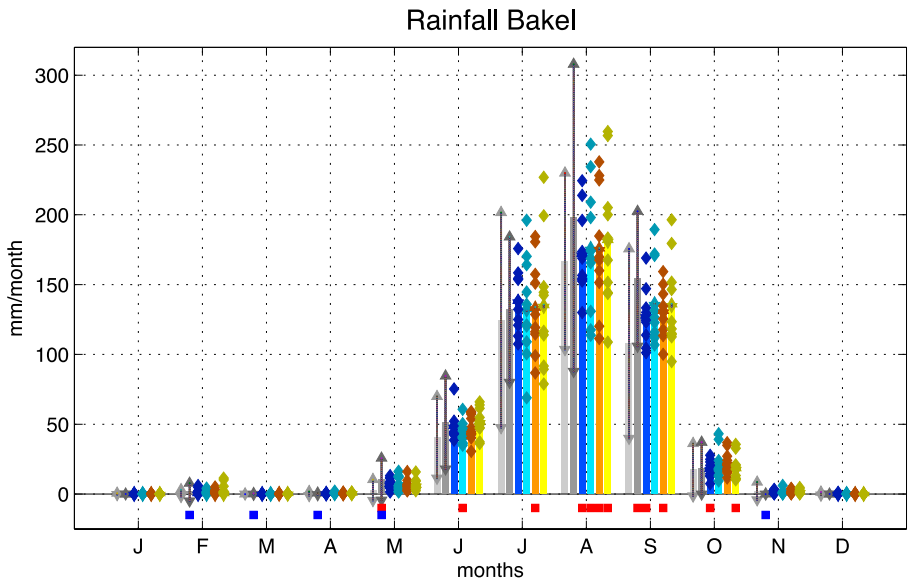


FIGURE 4: PROJECTED MONTHLY RAINFALL (TOP) AND ANOMALIES (BOTTOM) FOR THE BAKEL STATION



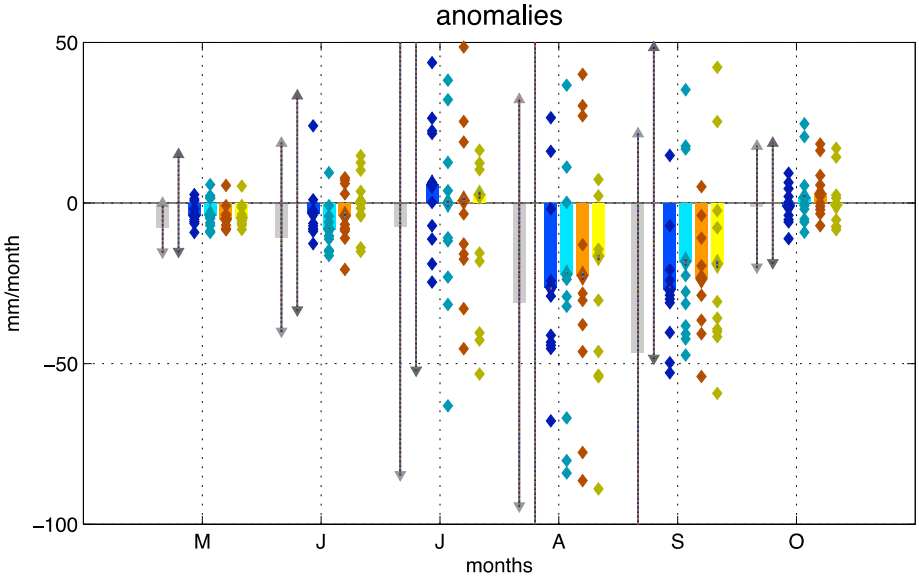
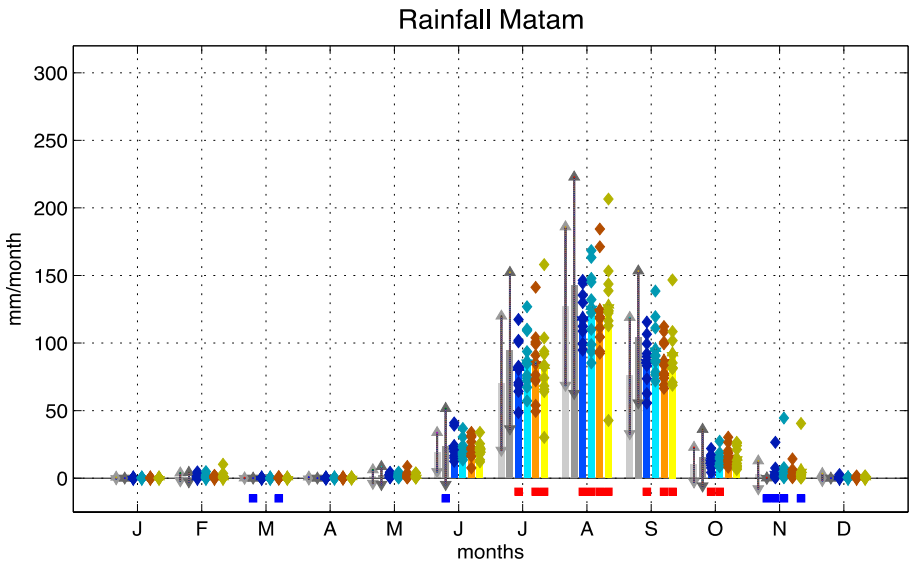
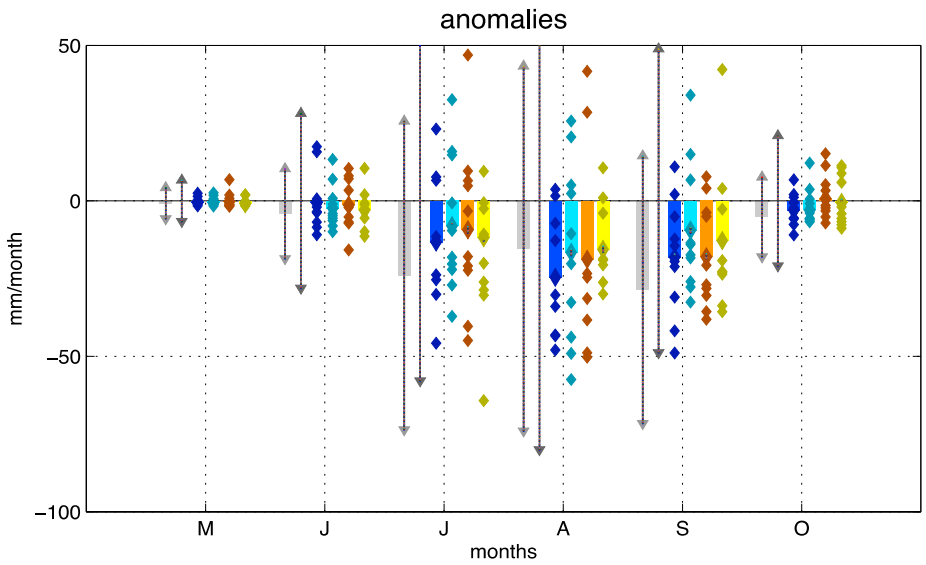


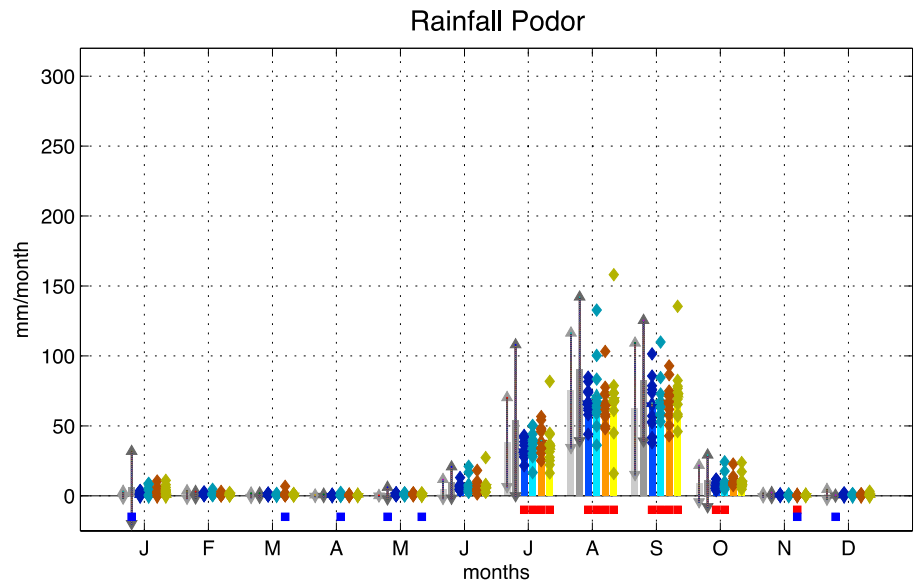
FIGURE 5: PROJECTED MONTHLY RAINFALL (TOP) AND ANOMALIES (BOTTOM)

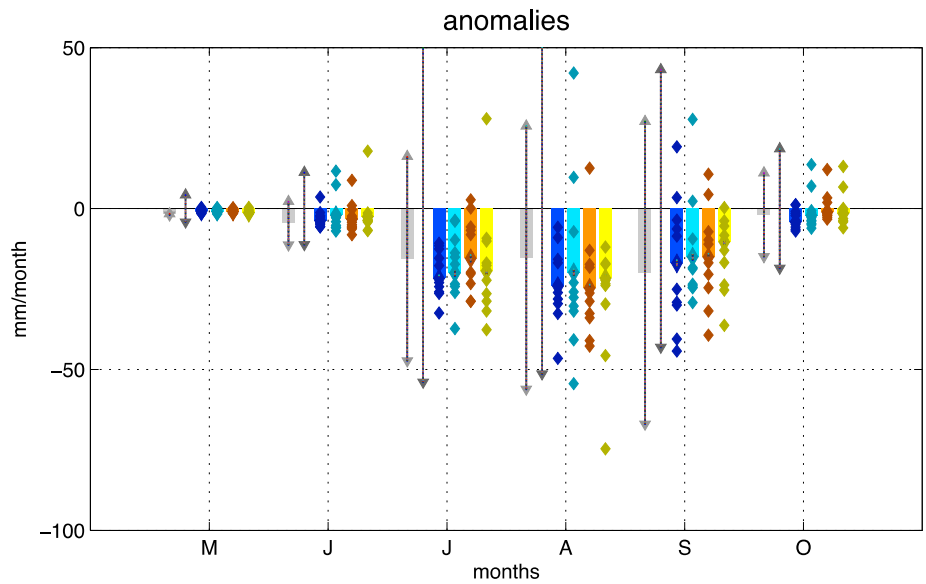




FOR THE MATAM STATION

FIGURE 6: PROJECTED MONTHLY RAINFALL (TOP) AND ANOMALIES (BOTTOM) FOR THE PODOR STATION





5.0 MULTIMODEL RESULTS FOR TEMPERATURE

5.1 Maximum Temperature

FIGURE 7: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE TAMBACOUNDA STATION

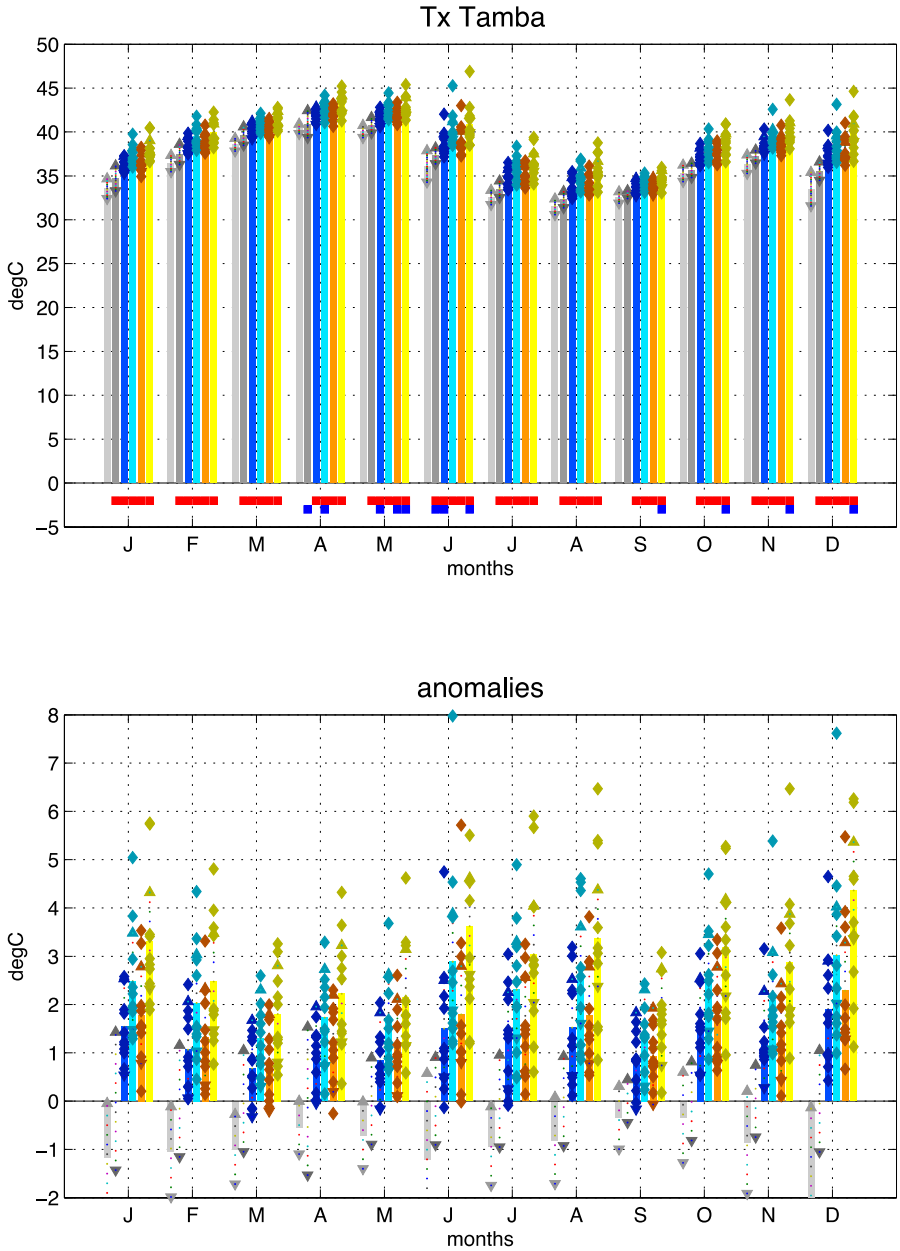


FIGURE 8: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE GOUDIRY STATION

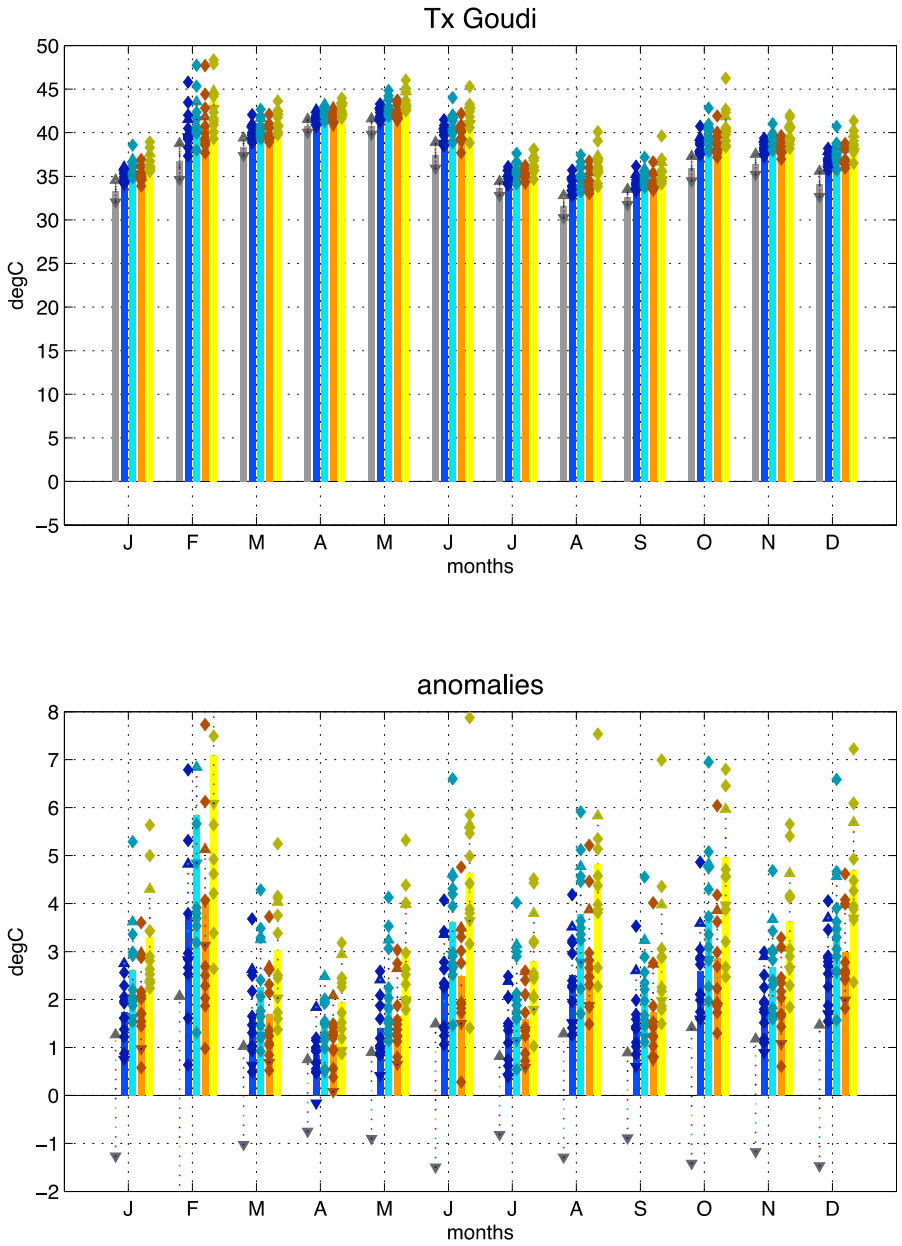
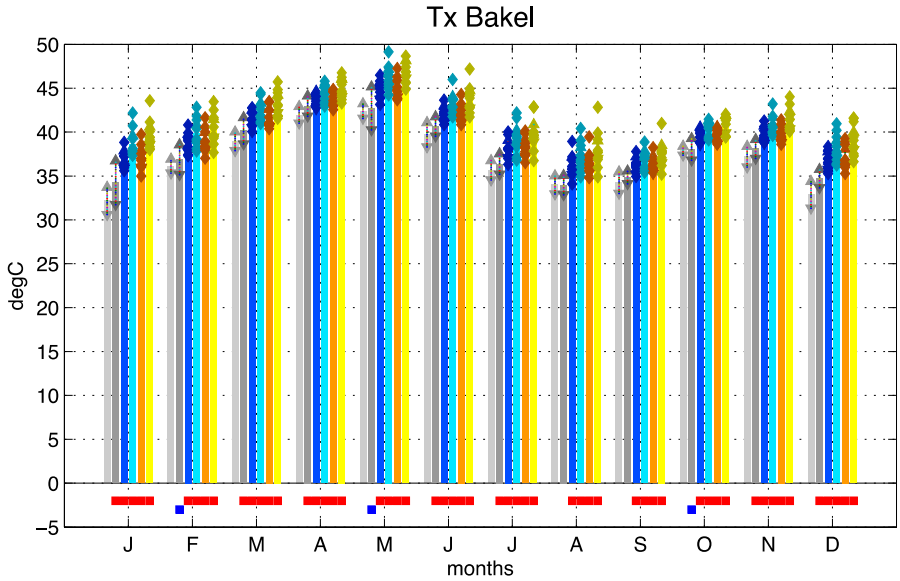


FIGURE 9: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE BAKEL STATION



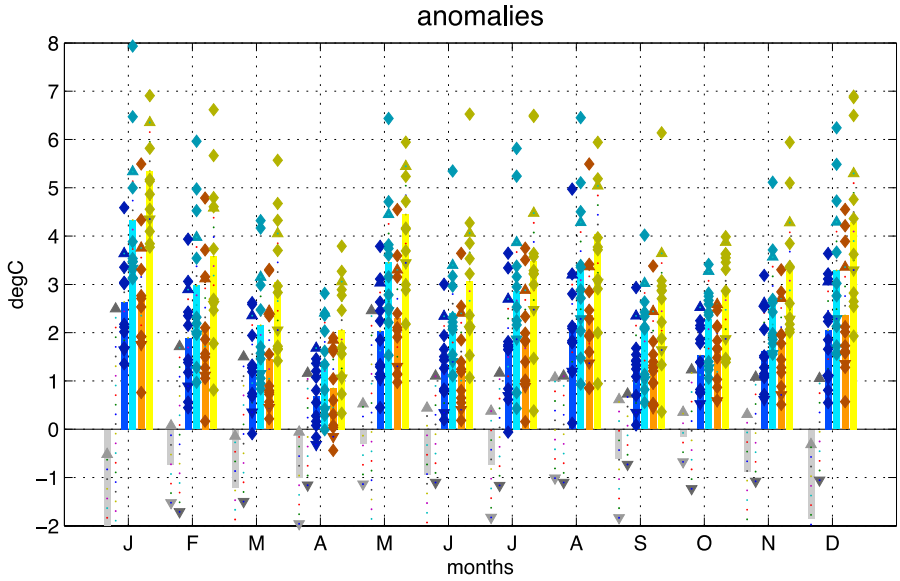


FIGURE 10: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE MATAM STATION

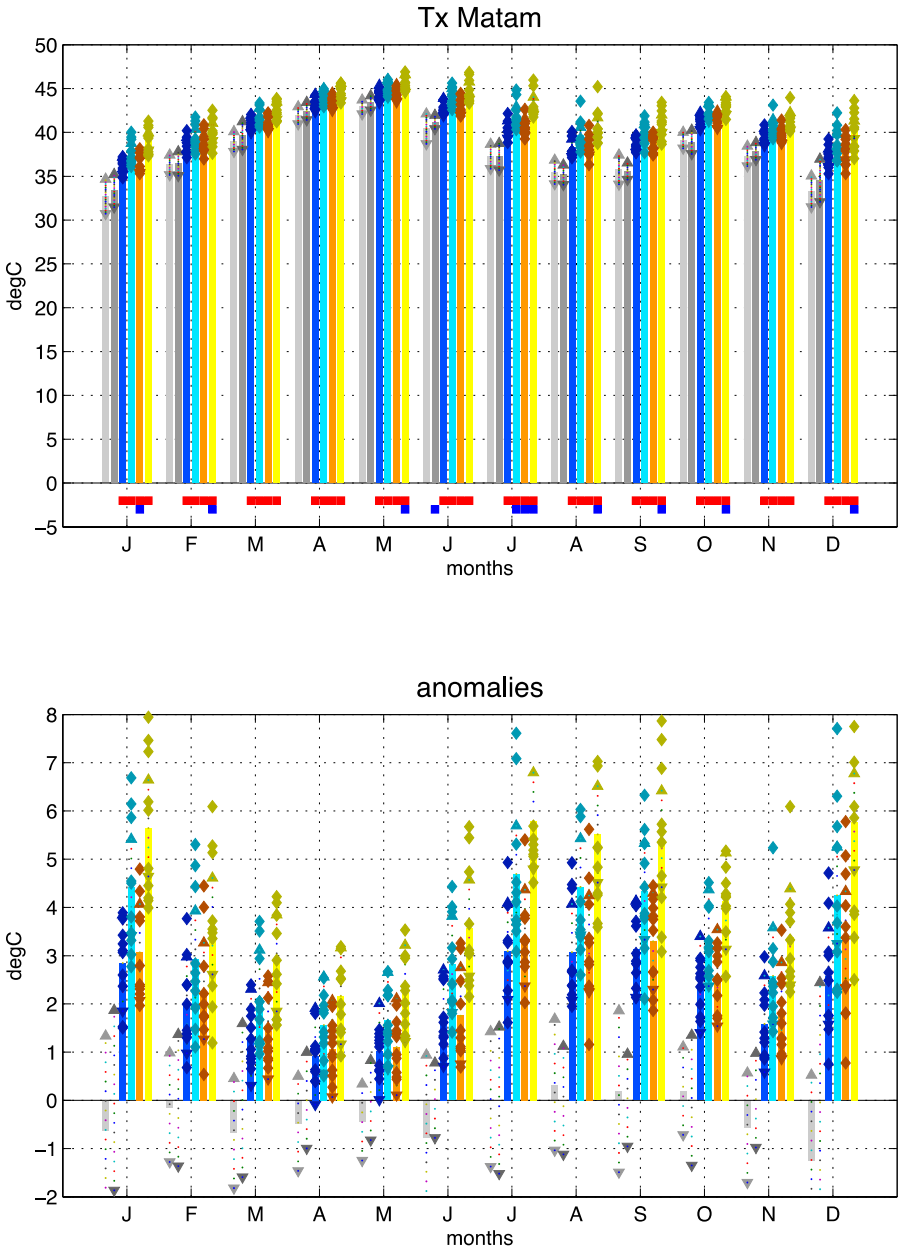
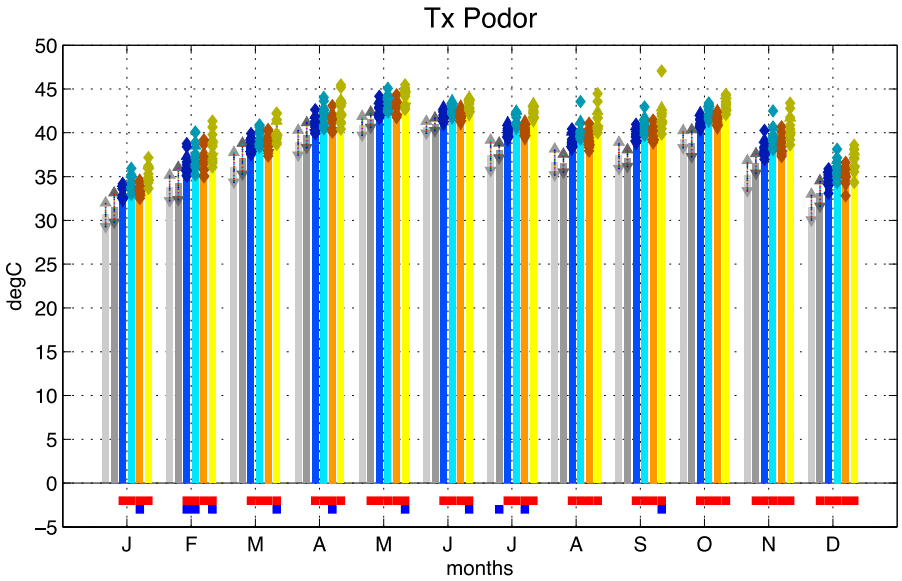
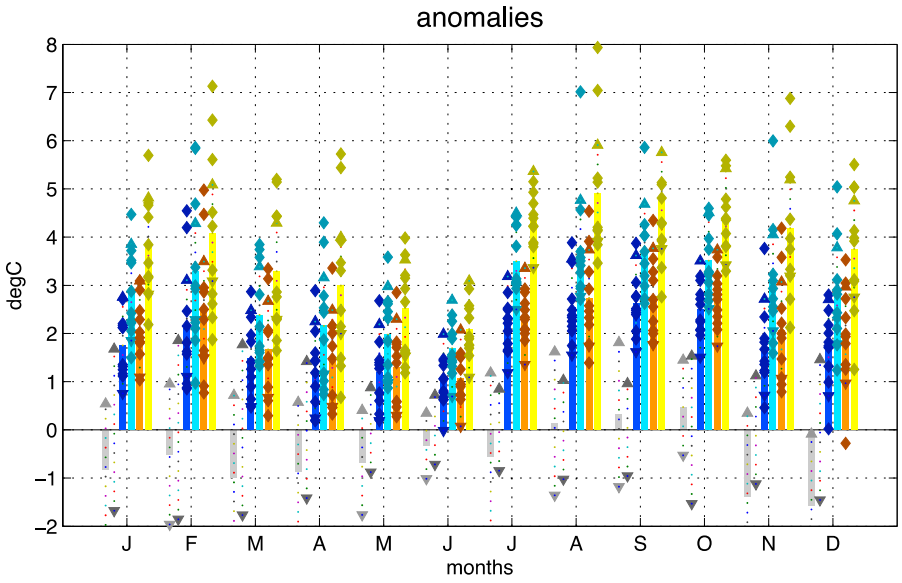


FIGURE 11: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE PODOR STATION





5.2 Minimum temperature

FIGURE 12: PROJECTED MONTHLY MAXIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE TAMBACOUNDA STATION

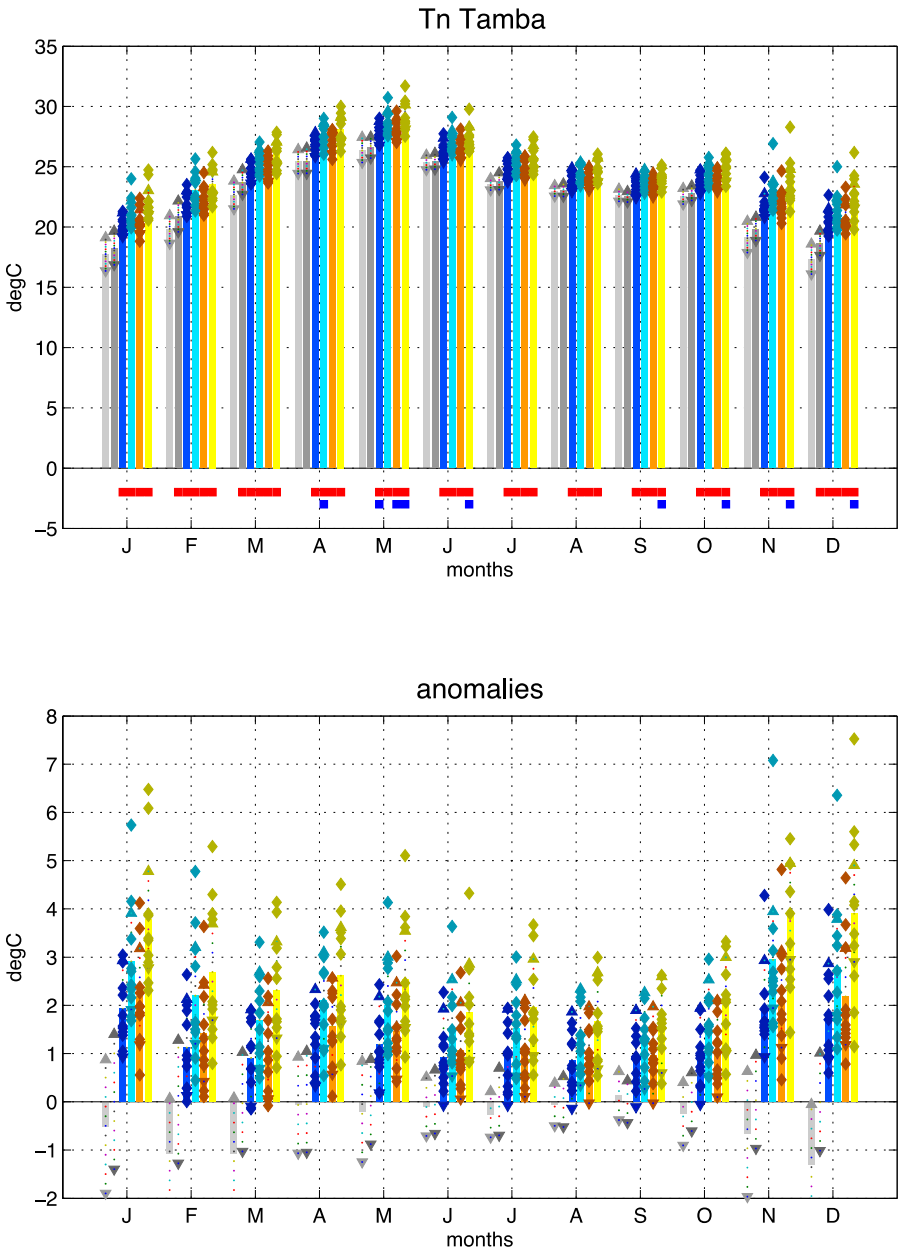


FIGURE 13: PROJECTED MONTHLY MINIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE GOUDIRY STATION

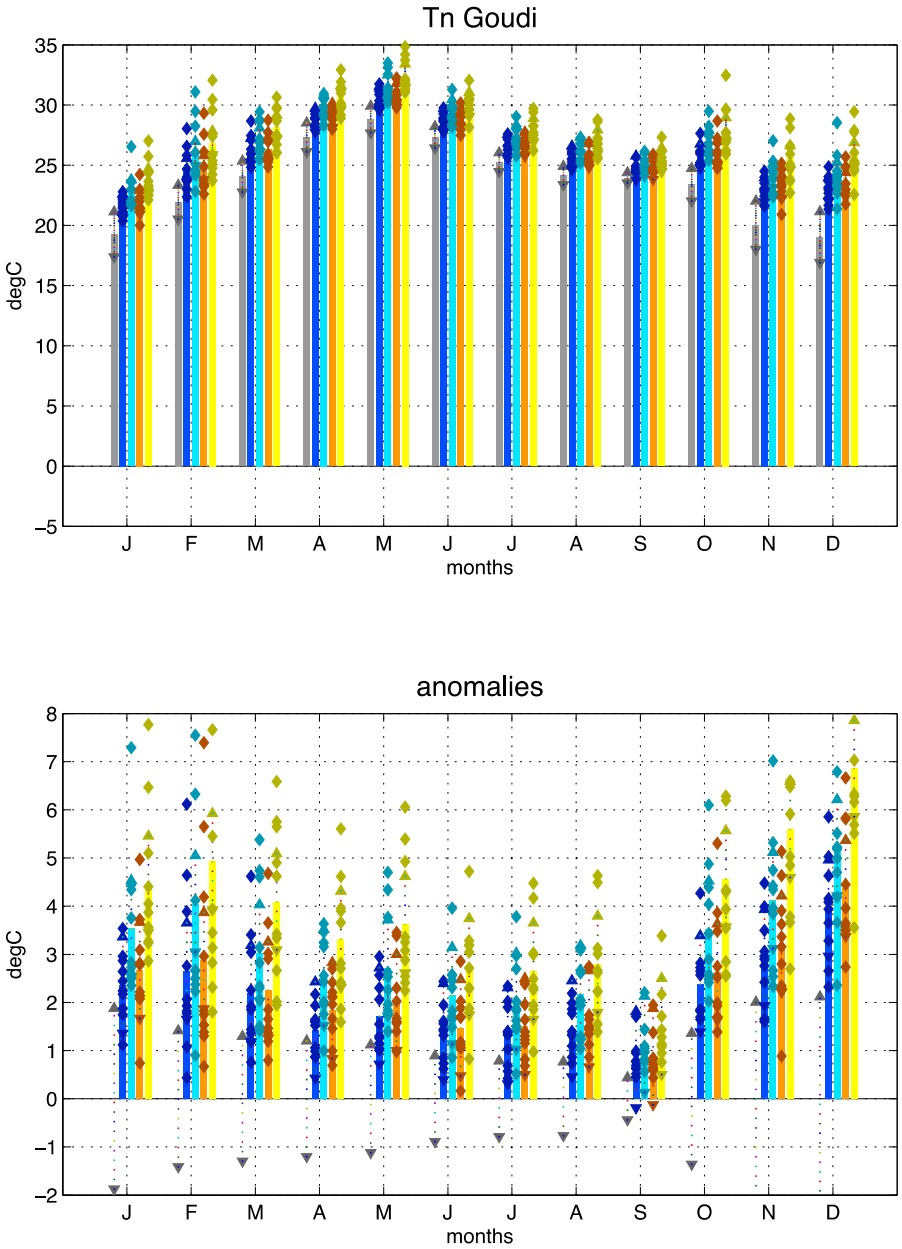


FIGURE 14: PROJECTED MONTHLY MINIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE BAKEL STATION

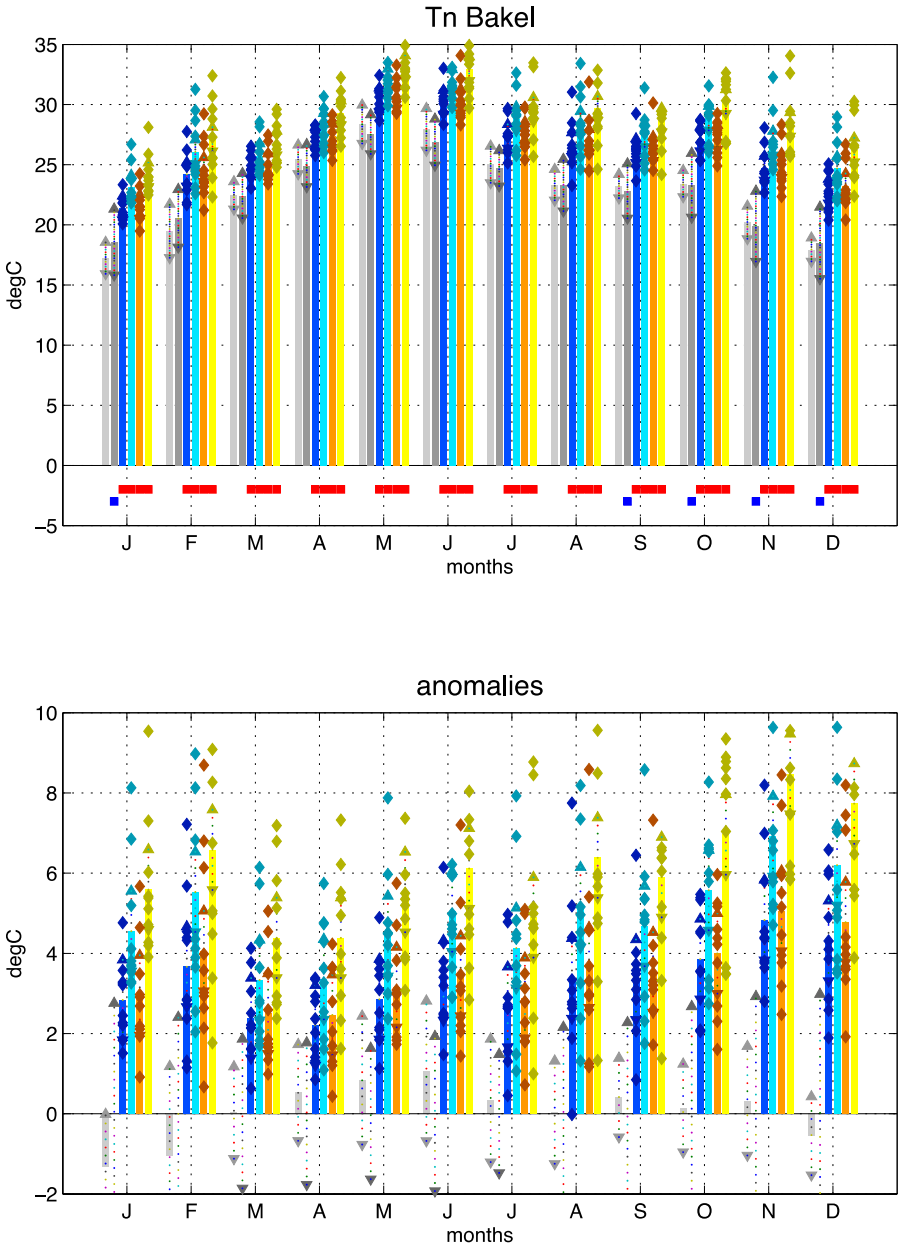
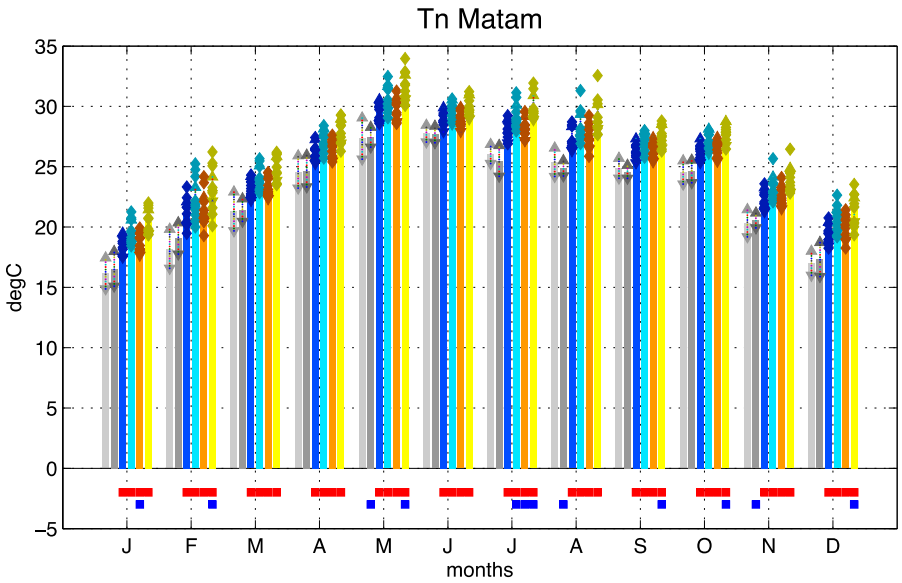


FIGURE 15: PROJECTED MONTHLY MINIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE MATAM STATION



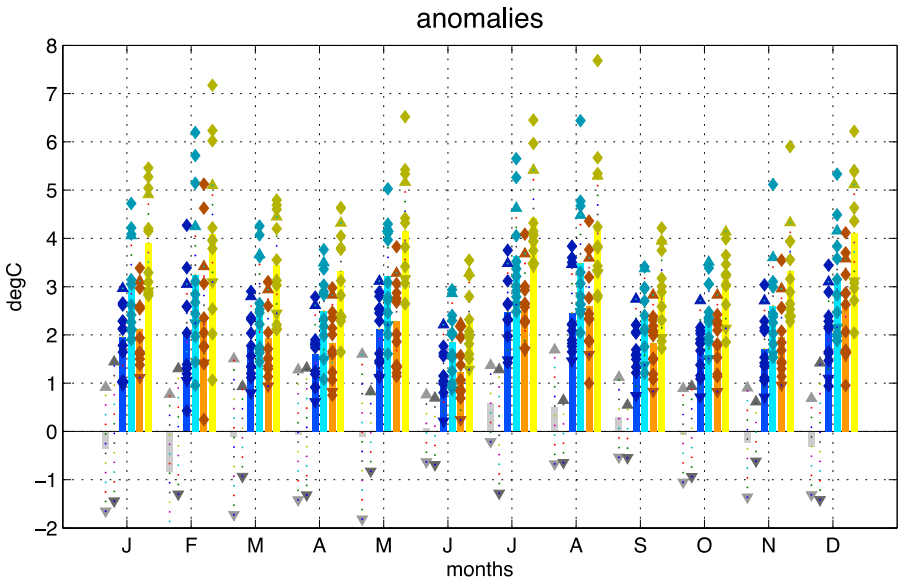
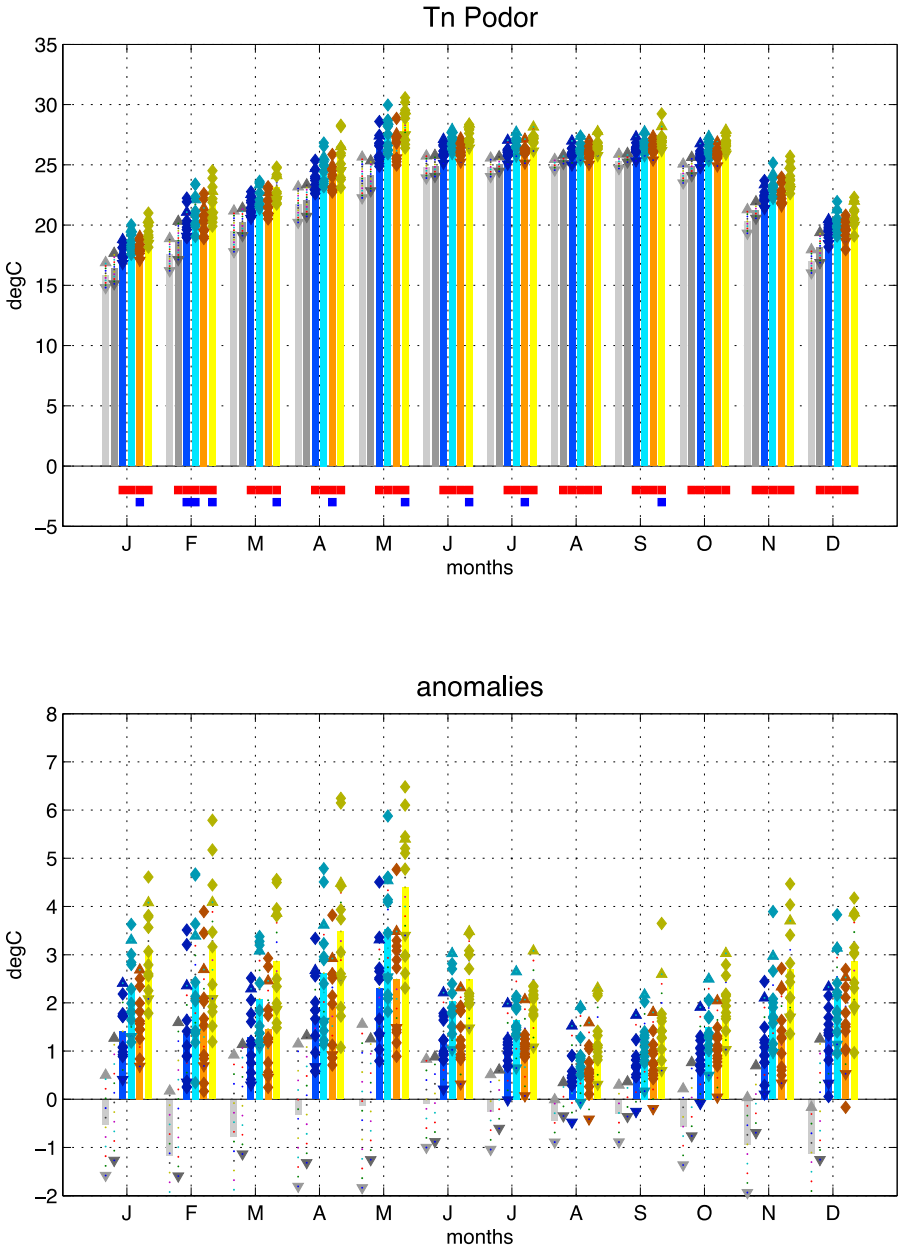


FIGURE 16: PROJECTED MONTHLY MINIMUM TEMPERATURE (TOP) AND ANOMALIES (BOTTOM) FOR THE PODOR STATION



6.0 SPREAD BETWEEN RESULTS

6.1 Rainfall

Annual Rainfall				RCP4.5				RCP8.5			
	Obs. 71–90	Obs. 91–10	Δ in %	2030	Δ in %	2050	Δ in %	2030	Δ in %	2050	Δ in %
Tamba	709.1	737.3	**-3.8**	625.3	**-15.2**	906.9	**23.0**	1095.2	**48.5**	989.8	**43.2**
				688.3	**-6.6**	693.0	**-6.0**	701.9	**-4.8**	708.9	**-3.9**
				638.1	**-13.5**	513.7	**-30.3**	582.1	**-21.0**	619.9	**-15.9**
Goudiry	609.8	617.0	**-1.2**	665.6	**7.9**	605.6	**-1.8**	632.9	**2.6**	655.7	**6.3**
				614.6	**-0.4**	494.5	**-19.9**	627.3	**1.8**	612.9	**-0.7**
				507.3	**-17.8**	468.3	**-24.1**	518.5	**-16.0**	553.8	**-10.2**
Bakel	463.8	558.3	**-16.9**	589.9	**5.7**	546.9	**-2.0**	566.4	**1.5**	632.7	**13.3**
				546.7	**-2.1**	374.4	**-32.9**	517.0	**-7.4**	496.4	**-11.1**
				502.3	**-10.0**	358.9	**-35.7**	406.7	**-27.2**	409.5	**-26.7**
Matam	308.9	392.3	**-21.3**	399.4	**1.8**	461.3	**17.6**	402.4	**2.6**	433.9	**10.6**
				232.6	**-40.7**	448.2	**14.2**	351.8	**-10.3**	337.4	**-14.0**
				277.7	**-29.2**	443.5	**13.1**	311.1	**-20.7**	248.7	**-36.6**
Podor	193.7	257.2	**-24.7**	310.0	**20.5**	268.6	**4.4**	134.0	**-47.9**	155.6	**-39.5**
				144.0	**-44.0**	303.5	**18.0**	272.7	**6.0**	251.6	**-2.2**
				184.6	**-28.2**	221.9	**-13.7**	234.4	**-8.9**	167.4	**-34.9**

6.2 Temperature (Tmax and Tmin)

Tmax					RCP4.5				RCP8.5			
		Obs. 71-90	Obs. 91-10	Δ in °C	2030	Δ in °C	2050	Δ in °C	2030	Δ in °C	2050	Δ in °C
Tamba	**wet season**	33.6	34.6	-1.0	37.5	**2.9**	34.9	**0.3**	35.6	**1**	36.5	**1.9**
					35.1	**0.5**	35.2	**0.6**	35.6	**1**	36.4	**1.8**
					35.8	**1.2**	36.2	**1.6**	35.9	**1.3**	36.2	**1.6**
	dry season	37.0	38.0	-1.0	40.5	**2.5**	38.9	**0.9**	38.9	**0.9**	38.9	**0.9**
					39.1	**1.1**	39.5	**1.5**	38.1	**0.1**	39.5	**1.5**
					38.9	**0.9**	40.3	**2.3**	38.6	**0.6**	41.9	**3.9**
Goudiry	**wet season**	N/A	34.0	N/A	36.5	**2.5**	38.6	**4.6**	35.9	**1.9**	37.1	**3.1**
					35.7	**1.7**	36.3	**2.3**	36.4	**2.4**	37.4	**3.4**
					36.3	**2.3**	36.3	**2.3**	36.4	**2.4**	36.4	**2.4**
	dry season	N/A	37.1	N/A	40.8	**3.7**	39.4	**2.3**	39.0	**1.9**	40.9	**3.8**
					38.6	**1.5**	39.5	**2.4**	37.9	**0.8**	39.3	**2.2**
					38.9	**1.8**	40.7	**3.6**	38.4	**1.3**	42.7	**5.6**
Bakel	**wet season**	36.3	36.8	-0.5	39.1	**2.3**	38.0	**1.2**	37.5	**0.7**	39.8	**3**
					37.9	**1.1**	38.5	**1.7**	38.6	**1.8**	40.1	**3.3**
					38.9	**2.1**	39.0	**2.2**	38.7	**1.9**	38.7	**1.9**
	dry season	37.3	38.5	-1.2	41.6	**3.1**	40.0	**1.5**	40.3	**1.8**	42.7	**4.2**
					39.5	**1**	40.8	**2.3**	40.0	**1.5**	40.7	**2.2**
					40.1	**1.6**	41.7	**3.2**	39.1	**0.6**	43.6	**5.1**
Matam	**wet season**	37.6	37.6	0.0	41.3	**3.7**	41.5	**3.9**	39.0	**1.4**	41.5	**3.9**
					40.1	**2.5**	41.5	**3.9**	40.3	**2.7**	42.0	**4.4**
					41.0	**3.4**	42.9	**5.3**	40.1	**2.5**	42.4	**4.8**
	dry season	37.6	38.2	-0.6	41.0	**2.8**	40.0	**1.8**	40.1	**1.9**	42.0	**3.8**
					39.6	**1.4**	40.8	**2.6**	39.8	**1.6**	40.4	**2.2**
					39.4	**1.2**	42.4	**4.2**	39.1	**0.9**	43.5	**5.3**
Podor	**wet season**	38.3	38.3	0.0	40.1	**1.8**	41.8	**3.5**	39.2	**0.9**	42.0	**3.7**
					40.3	**2**	41.3	**3**	39.6	**1.3**	42.3	**4**
					40.9	**2.6**	41.9	**3.6**	40.7	**2.4**	41.2	**2.9**
	dry season	35.2	36.2	-1.0	38.8	**2.6**	38.4	**2.2**	37.8	**1.6**	38.6	**2.4**
					36.8	**0.6**	38.4	**2.2**	36.8	**0.6**	37.7	**1.5**
					37.2	**1**	40.0	**3.8**	37.0	**0.8**	40.9	**4.7**

Tmin					RCP4.5				RCP8.5			
		Obs. 71-90	Obs. 91-10	Δ in °C	2030	Δ in °C	2050	Δ in °C	2030	Δ in °C	2050	Δ in °C
Tamba	**wet season**	23.4	23.5	-0.1	25.3	**1.8**	24.0	**0.5**	24.4	**0.9**	24.9	**1.4**
					24.1	**0.6**	24.9	**1.4**	24.0	**0.5**	25.0	**1.5**
					24.5	**1**	24.7	**1.2**	24.0	**0.5**	25.2	**1.7**
	dry season	21.2	22.0	-0.8	24.9	**2.9**	23.2	**1.2**	23.1	**1.1**	23.1	**1.1**
					23.3	**1.3**	23.8	**1.8**	23.0	**1**	23.5	**1.5**
					23.0	**1**	24.5	**2.5**	23.3	**1.3**	24.9	**2**
Goudiry	**wet season**	N/A	24.8	N/A	26.7	**1.9**	27.9	**3.1**	25.8	**1.0**	27.0	**2.2**
					25.9	**1.1**	26.7	**1.9**	25.8	**1.0**	27.2	**2.4**
					26.4	**1.6**	26.2	**1.4**	25.5	**0.7**	26.9	**2.1**
	dry season	N/A	22.9	N/A	26.8	**3.9**	25.7	**2.8**	25.5	**2.6**	27.6	**4.7**
					24.9	**2**	26.1	**3.2**	24.9	**2**	25.1	**2.2**
					25.3	**2.4**	26.9	**4**	25.0	**2.1**	27.6	**4.7**
Bakel	**wet season**	24.7	24.3	0.4	29.3	**5**	26.8	**2.5**	26.2	**1.9**	29.7	**5.4**
					26.7	**2.4**	28.7	**4.4**	27.9	**3.6**	30.4	**6.1**
					28.2	**3.9**	28.1	**3.8**	25.8	**1.5**	30.2	**5.9**
	dry season	21.5	21.9	-0.4	26.9	**5**	24.8	**2.9**	24.9	**3**	28.1	**6.2**
					24.1	**2.2**	25.6	**3.7**	23.7	**1.8**	25.5	**3.6**
					24.8	**2.9**	26.7	**4.8**	24.7	**2.8**	27.3	**5.4**
Matam	**wet season**	25.7	25.4	0.3	27.7	**2.3**	28.2	**2.8**	26.5	**1.1**	28.2	**2.8**
					27.2	**1.8**	27.8	**2.4**	27.5	**2.1**	28.8	**3.4**
					27.8	**2.4**	29.2	**3.8**	26.5	**1.1**	30.3	**4.9**
	dry season	20.7	21.0	-0.3	23.7	**2.7**	23.1	**2.1**	22.8	**1.8**	24.9	**3.9**
					22.3	**1.3**	23.6	**2.6**	22.2	**1.2**	23.3	**2.3**
					22.4	**1.4**	25.1	**4.1**	22.9	**1.9**	26.2	**5.2**
Podor	**wet season**	24.8	25.5	0.7	26.1	**0.6**	26.8	**1.3**	25.5	**0**	27.0	**1.5**
					26.1	**0.6**	25.7	**0.2**	26.2	**0.7**	27.0	**1.5**
					26.3	**0.8**	26.7	**1.2**	25.6	**0.1**	27.3	**1.8**
	dry season	19.4	20.1	-0.7	22.4	**2.3**	22.2	**2.1**	21.8	**1.7**	22.6	**2.5**
					20.7	**0.6**	21.2	**1.1**	20.6	**0.5**	22.4	**2.3**
					21.3	**1.2**	22.0	**1.9**	20.3	**0.2**	24.6	**4.5**

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES U – W

SEPTEMBER 2014

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ARCC

African and Latin American Resilience to Climate Change Project

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ANNEX U. STRATÉGIES D'ADAPTATION AUTONOMES

BUREAU D'ANALYSES MACRO-ÉCONOMIQUES

ETUDE ARCC

Évaluation de la vulnérabilité du Sénégal au changement climatique et analyse des options

STRATÉGIES D'ADAPTATION AUTONOMES

FÉVRIER 2014

SUMMARY

Rural populations have many diverse means of subsistence (agricultural and pastoral activities, exploitation of natural resources, trade in agricultural products, animal husbandry, and forestry). Despite this, the negative impact caused by climate variability is gaining momentum in rural areas. Thus, these populations are becoming more vulnerable. This vulnerability prompts short- and medium-term strategies that deserve consideration.

The present study on autonomous adaptation strategies fits into this context. Indeed, as a part of assessing Senegal's vulnerability to climate change and analyzing the options, focus groups were conducted in the 18 villages targeted by the ARCC project. The objective of these focus groups was to analyze the autonomous adaptation strategies and initiatives, both individual and collective, taken by villagers to reduce vulnerability to climate change or variability.

These focus groups highlighted several strategies developed by agriculture farmers and shepherds.

Shepherds aim not only to deal with the decrease in pastureland and the drop in rainfall, but also to increase income from this activity. This consists primarily of: a) transhumance, which is practiced by the populations of certain villages in the North area (Ouro Silamaka, Asndé Balla, Thiancone Hiraye, Ouro Cebbo); b) selling livestock to support themselves in times of need; c) taking advantage of opportunities, such as holiday periods, to sell livestock in order to maximize profit; d) the introduction of new species of sheep; and e) raising more small ruminants (sheep and goats) than cattle (Gambi, Sinthiou Madina, Kiriré 1 and Thiancone Hiraye).

Agricultural farmers have developed many strategies, depending on the particular growing area, to deal with the drop in rainfall and soil fertility and to increase income. The strategies consist of a) replacing the old varieties of grain crops (millet, sorghum, and corn) with early varieties of dry grains in some villages (Sinthiou Madina, Mbakhanabé, Samba Kolo, Thiancone Hiraye); b) substituting millet and sorghum crops with corn crops to deal with bird attacks and locust threats; and c) developing more vegetable crops (sweet and bitter eggplant, lettuce, carrots, cabbage, turnips, peppers, cucumbers, squash, tomato, and onions).

Furthermore, migration considerably contributes to the reduction of vulnerability of the agricultural and pastoral exploitations. In short, the analysis of autonomous adaptation strategies highlights the scope of action that the agriculture farmers and shepherds have to reduce their vulnerability.

RESUME

Les moyens de subsistance des populations rurales sont très importants et diversifiés (activités agricoles et pastorales, de l'exploitation des ressources naturelles, du commerce des produits agricoles, d'élevage, forestiers). Malgré leur importance et leur diversité, l'impact négatif de la variabilité climatique prend de l'ampleur dans les zones rurales. Ainsi, ces populations sont de plus en plus exposées à la vulnérabilité. Cette dernière induit des stratégies de court et moyen terme qui méritent réflexions.

C'est dans ce cadre que s'inscrit cette étude sur les stratégies d'adaptation autonomes. En effet, dans le cadre de l'évaluation de la vulnérabilité du Sénégal au changement climatique et l'analyse des options, des focus group ont été menés dans les 18 villages ciblés par le projet ARCC. L'objectif de ces focus était d'analyser les stratégies d'adaptation autonomes en mettant le focus sur les initiatives ou mesures individuelles ou collectives visant à réduire la vulnérabilité à la variabilité ou au changement climatique.

Ces focus ont fait ressortir plusieurs stratégies développées par les agriculteurs et les pasteurs, visant à réduire leurs vulnérabilités par rapport au changement climatique.

D'une part, les stratégies des pasteurs visent non seulement à faire face à la diminution du pâturage et à la baisse de la pluviométrie mais aussi à augmenter les revenus tirés de cette activité. Il s'agit principalement de: i) la transhumance qui est pratiquée par les populations de certains villages de la zone Nord (Ouro Silamaka, Asndé Bala, Thiancone Hiraye, Ouro Cebbo); ii) la stratégie qui consiste à vendre le bétail pour subvenir à des besoins ponctuels, iii) celle qui vise à saisir les opportunités comme les périodes de fêtes pour vendre le bétail en vue de maximiser les profits, iv) l'introduction de nouvelles espèces d'ovins et v) la stratégie qui consiste à élever plus de petits ruminants (ovins et caprins) que de bovins (Gambi, Sinthiou Madina, Kiriré 1 et Thiancone Hiraye).

D'autre part, plusieurs stratégies visant à faire face à la baisse de la pluviométrie, à la baisse de la fertilité des sols et à augmenter les revenus ont été développées par les agriculteurs. Ces stratégies sont nombreuses et varient en fonction des zones. Ces stratégies consistent à: i) remplacer les variétés anciennes de cultures céréalières (mil, sorgho et mais) par des variétés hâtives de céréales sèches dans certains villages (Sinthiou Madina, Mbakhanabé, Samba Kolo, Thiancone Hiraye); ii) substituer la culture du Mil et Sorgho par celle du Maïs, pour faire face aux attaques des oiseaux ravageurs et aux périls acridiens; iii) développer plus de cultures maraîchères (aubergine doux et amère, salade, carotte, chou, navet, piment, concombre, courge, tomate oignon).

En outre, la migration contribue de façon considérable à la réduction de la vulnérabilité des exploitations agricoles et pastorales. En somme, l'analyse des stratégies d'adaptation autonomes fait ressortir les marges de manœuvre dont disposent les agriculteurs et les pasteurs pour réduire leur vulnérabilité.

INTRODUCTION

Les activités dominantes des départements de Matam, Kanel, Bakel et Goudiry restent l'agriculture pluviale et ou irriguée et l'élevage extensif. Ces zones sont également caractérisées par des températures élevées, des précipitations irrégulières et la désertification. Ces caractéristiques ont profondément influé sur les activités productives (agriculture pluviale et l'élevage).

Dans le cadre d'un projet de recherche sur l'évaluation de la vulnérabilité aux changements climatiques, les zones Nord (Matam et Kanel) et Sud (Bakel et Goudiry) ont été choisies en raison du niveau élevé d'insécurité alimentaire. Ce dernier est à l'origine de stratégies d'adaptation qui méritent réflexions.

L'objet du présent rapport est d'analyser les stratégies d'adaptation aux changements climatiques en mettant l'accent sur les différences entre les villages de la zone Nord (Thiancone Hiraye, Hontorbé, Kiriré I, Asndé Balla, Ouro Cebo, Ouro Silamako, Boulone Samba Djadji) et ceux de la zone Sud (Boynguél Bamba, Gambi, Godioyél Bocar Yoro, Boulel, Mbakanabé, Koar, Sinthiou Madina et Samba Kolo). Ainsi, les initiatives ou mesures individuelles ou collectives visant à réduire la vulnérabilité à la variabilité ou aux changements climatiques feront l'objet d'une attention particulière.

Pour analyser ces stratégies d'adaptation autonomes, une première mission de prospection avait permis d'informer les chefs de villages ciblés de la tenue des enquêtes et de collecter des informations préliminaires sur les activités économiques (agriculture, élevage, commerce, etc.) et les contraintes de ces activités.

Un guide de discussion a permis de recueillir des informations sur les moyens de subsistance et de questionner les changements dans les types et la gestion des cultures, dans la gestion et les pratiques d'élevage et dans les moyens de subsistance. Ce guide est structuré autour de trois principaux points:

- Les caractéristiques des moyens de subsistance
- Les types de changements durant les 20 dernières années
- Les changements spécifiques durant les 20 dernières années

Dans chaque village un focus pour les femmes et un focus pour les hommes avaient été tenus. Ces focus ont permis aux différentes tranches d'âge (jeunes, adultes et vieux) de participer et donner leurs avis sur les questions abordées. Pour des raisons de représentativité, les participants ont été choisis dans tous les quartiers, les clans, les castes et les groupes religieux. De même, les groupes de discussions étaient composés de ménages qui développent différentes stratégies de moyens d'existence. Le guide de discussions ainsi que les listes de présence des participants et leur âge seront joints en annexe.

Le présent rapport synthétise et analyse les résultats des différents focus effectués dans les 15 villages ciblés. Il est structuré en six parties:

- La première partie analyse les caractéristiques actuelles des moyens de subsistance des villages.
- Le deuxième point permet d'avoir un regard historique sur les transformations de ces moyens de subsistance.

- La troisième partie aborde les changements spécifiques aux types et à la gestion des cultures.
- Le point quatre met le focus sur les changements spécifiques à la gestion et aux pratiques d'élevage.
- La cinquième partie met l'accent sur les changements importants des moyens de subsistance dans l'agriculture et l'élevage.
- Le dernier point aborde les contraintes et recommandations des populations locales.

CARACTERISTIQUES DES MOYENS DE SUBSISTANCE

Activités agricoles

Les spéculations cultivées par les exploitations sont assez diversifiées. Elles concernent principalement les céréales sèches (mil, sorgho, maïs) et l'arachide, et dans une moindre mesure le niébé, le gombo, l'oseille, les courges et la pastèque. Elles sont généralement pratiquées dans le diéri. À côté des cultures hivernales, dans certaines exploitations, on note la présence de cultures maraichères (oignon, chou, aubergine, navet, salade et carotte) produites souvent par les femmes soit durant l'hivernage, soit durant la saison sèche froide. On note aussi la présence de la riziculture dans certaines zones qui est surtout pratiquée par les femmes.

La préparation des travaux agricoles débutent en avril pour finir au mois de juin avec le démarrage de l'hivernage. Les travaux consistent au défrichage et à l'élagage des arbres et arbustes et à l'épandage de la matière organique (bouse de vache ou déchets ménagers). Pour éviter l'accentuation de l'appauvrissement du sol, certains agriculteurs le font par intervalle de trois ans. Les outils généralement utilisés sont la hache, la machette et les râteaux. Par la suite, pour les travaux de labour et de binage, les outils à traction animale (houe sine, charrues) sont utilisés. Ces travaux sont pour la plus part réalisés par les jeunes souvent accompagnés des femmes. Les semis sont réalisés avec les premières pluies utiles soit avec des semoirs, soit à l'aide d'une grande houe appelée « jinda » (une personne fait un petit trou et l'autre le referme du sable après y avoir mis la semence). Le désherbage est effectué avec les outils tractés et avec des outils manuels (houe traditionnel "*Dialo warongué*" ou "*ngoss ngoss*" en fonction des zones) tous les trois jours pendant un à deux mois selon le niveau d'infestation. Le désherbage se fait entre mi-juillet et fin août et il est strictement réservé aux hommes mais les femmes le font pour leurs champs. Pour les céréales, à la maturité, un effort supplémentaire est réalisé à travers le gardiennage (enfants) pour lutter contre les oiseaux granivores. On note aussi un effort de gardiennage contre la divagation des animaux. Pour la récolte qui peut s'étaler sur deux mois (octobre-novembre), les agriculteurs utilisent des couteaux et des machettes, dès fois des outils tractés (souleveuse, bati arara) pour l'arachide. Le battage est généralement réalisé dans les concessions pour les céréales alors que pour l'arachide, il est fait dans les champs. Les récoltes, stockées dans les greniers traditionnels ou dans les habitations, sont destinées à l'autoconsommation mais en cas d'excédents ou de besoin urgent, une partie peut être commercialisée dans les marchés hebdomadaires.

Le maraichage est pratiqué principalement durant la saison sèche froide mais il arrive dans certaines zones qu'on le fasse pendant l'hivernage. Les parcelles sont sommairement clôturées avec du matériel de récupération ou de branches issues de l'élagage des arbres ou d'épineux afin de faire face à la divagation des animaux. Les outils généralement utilisés sont manuels et

rustiques ainsi que l'arrosage. Néanmoins, certaines exploitations situées dans des zones aménagées bénéficient d'une irrigation gravitaire avec une alimentation provenant d'un cours d'eau ou de canaux. Les surfaces exploitées ne sont pas importantes et les travaux sont souvent réalisés par les femmes. Une partie de la production est autoconsommée mais la majeure partie est commercialisée dans le village ou les marchés hebdomadaires.

Activités pastorales

Les activités pastorales viennent juste après les activités agricoles. Les troupeaux sont souvent constitués par les bovins, les ovins et les caprins. Les autres animaux présents dans les exploitations sont la volaille et dans une moindre mesure les équins et les asins. Les troupeaux les plus importants sont constitués, en fonction des zones, de bovins ou de petits ruminants. Selon la taille du troupeau, l'élevage est soit sédentaire, soit transhumant. Ainsi durant l'hivernage, le bétail n'est pas loin du village car pouvant profiter de la qualité et de la quantité du tapis herbacés alors que durant la période sèche (soudure), les animaux sédentaires profitent des résidus de récolte et de l'herbe asséchée. Dans les villages situés dans la zone Nord, les troupeaux transhumants se déplacent vers le sud ou à l'est pour aller vers des parcours plus riches avec leur propriétaire dans des campements. Une autre forme d'exploitation des animaux est l'embouche bovine ou ovine qui demande une préparation pour le stockage du fourrage mais aussi une certaines assise financière pour pouvoir disposer d'aliments concentrés et de médicaments. En effet, avec l'apparition de nouvelles pathologies, les éleveurs font recours aux services vétérinaires pour préserver leurs animaux des maladies contagieuses. De plus, la vaccination du bétail se fait annuellement par les services du ministère de l'élevage à raison de 50 franc CFA par têtes de petits ruminants et 60 à 75 francs CFA par têtes de bovin. L'élevage est surtout naisseur, c'est pourquoi les animaux sont en général rarement commercialisés sauf en cas de besoin urgent. Toutefois, dans certaines zones 30% des bovins mâles sont écoulés annuellement pour le renouvellement du troupeau par l'achat de femelles plus productives. La commercialisation se fait généralement dans les marchés hebdomadaires qui sont souvent des marchés de regroupement avant d'être envoyé dans les grands centres urbains. Les principaux acteurs de cette commercialisation sont les « téfankés » qui peuvent être originaires des villages ou disposer de rabatteurs pour leur faciliter l'acquisition des animaux. La vente des animaux est souvent en relation avec les fêtes religieuses (Tabaski pour les ovins ; retour des pèlerins de la Mecque pour les bovins). Les sous-produits comme le lait, l'huile de beurre et le lait caillé ont généralement un circuit commercial court dans le village ou dans les marchés hebdomadaires et sont souvent sous la responsabilité des femmes.

Gestion des ressources naturelles

L'accès aux terres se fait généralement par héritage. Les terres ne sont pas vendues mais peuvent être obtenue par location ou par don. Elles sont utilisées pour l'habitation, pour l'agriculture et dans une moindre mesure pour le pâturage. Pour ce dernier, on note la présence de couloir de transhumance dans certaines zones pour éviter les conflits entre agriculteurs et éleveurs.

Pour ce qui est des ressources en eau, on note l'apparition de plus en plus des bornes fontaines et des forages mais l'utilisation des puits restent importante dans certaines zones ainsi que celle des mares temporaires durant l'hivernage. Les forages peuvent être équipés avec une pompe électrique ou manuelle mais ont la caractéristique de tomber souvent en panne. Durant la saison sèche, on peut noter la baisse du débit des puits ou le tarissement des mares, ce qui peut entrainer une concurrence entre les hommes et les animaux.

Les produits forestiers sont fortement utilisés par les populations qui en disposent pour la construction (bois kolé et dioyé pour fabrication des cases,…) des habitations, des clôtures (maisons, champs, étables) et le chauffage (bois morts ou tige ou tronc), pour la consommation et la commercialisation (fruits forestiers saisonniers tels que jujubier, baobab, balanites, gomme arabique, gomme « mbepp » ; etc…), pour la médecine traditionnelle (Yéloko ett dokki : plantes contre le rhume, …).

Mobilité dans les villages

Généralement, on note une émigration plus ou moins importante selon les villages. Cette émigration peut être temporaire et concerne souvent les jeunes qui vont à l'école ou à la recherche d'un emploi durant la saison sèche. Ils reviennent lors des grandes fêtes religieuses et au début de l'hivernage pour participer aux activités champêtres et n'ont pas un impact économique important sur le ménage. De plus en plus, les villageois disposent d'écoles primaires dans leur village ou dans un village voisin mais au-delà du cycle primaire, les élèves sont obligés d'aller dans des localité plus grande pour continuer. Cependant, ils sont souvent confronter à divers problèmes (hébergement, financiers, mariage précoce pour les filles…), ce qui les pousse à abandonner les études. Une autre forme d'émigration est plus lointaine et durable dans les régions à fort potentiel économique au niveau national mais aussi dans les pays de la sous-région, en Europe ou aux États unis principalement. Cette forme d'émigration a un fort impact économique pour le ménage et pour le village.

Transhumance

La transhumance démarre avec le début de la saison sèche à la recherche de pâturage et concerne les bovins et les petits ruminants. Les jeunes souvent accompagnés de quelques adultes ou des bergers sont responsables des animaux. Différents couloirs de transhumances sont identifiés pour éviter les conflits avec les agriculteurs qui font des cultures de contre saison. Les principales destinations sont le ferlo, le Mali ou le sud-est du Sénégal (Tambacounda et Kédougou).

1.1. VULNÉRABILITÉS PERÇUE

Pour l'agriculture, le déficit hydrique, l'absence d'outils agricoles appropriés ou modernes, le manque d'intrants (engrais et produits phytosanitaires) restent les principales difficultés des populations à côté des invasions acridiennes, du développement des parasites, des oiseaux granivores, de la faible disponibilité de semences améliorées. Le manque de grillage est aussi un problème récurrent contre la divagation des animaux.

L'élevage connait des difficultés consécutives à la raréfaction des pâturages, à l'apparition de nouvelles maladies et surtout au problème d'accès à l'eau durant la saison sèche. Il faut ajouter aussi l'absence d'aliments de bétail (concentrés et fourrages) durant les périodes cruciaux (soudure) mais aussi la faible représentativité des vétérinaires dans la zone et des produits vétérinaires pour faciliter le soin des animaux. La conséquence est le faible niveau de reproduction du bétail.

Les revenus se raréfient avec la baisse de la productivité agricole et du faible rendement des produits d'élevage. De plus, la dégradation des ressources naturelles a eu un impact négatif sur le niveau et la diversité des revenus.

Liens externes

Les relations avec l'extérieur se matérialisent par de nombreuses interventions étatiques (construction d'écoles, de cases de santé, de postes de santé), de projets (PRODAM), d'ONG (Yaanjendé, Vepsa, Zaress, ONG Set Setal, ONG Contre Part). Ces acteurs interviennent dans plusieurs domaines du développement rural (nutrition, sécurité alimentaire, éducation, santé, agriculture, élevage, assainissement, alphabétisation, etc.). Certains villages comme Boulone Samba Djadji et Kiriré I ne bénéficient pas de ces infrastructures étatiques (écoles, cases de santé, etc.).

En ce qui concerne le commerce, on note la présence de commerçants qui détiennent des boutiques qui ravitaillent les habitants en denrées alimentaires de base (riz, huile, sucre), condiments et produits d'entretien (savon). De temps en temps, certains banas-banas achètent les productions juste après les récoltes. Même si la quasi-totalité des villages ciblés ne disposent pas de marchés, les chefs lieux de CR et les grands villages les plus proches disposent généralement de marchés hebdomadaires ou "*loumas*". Ces derniers facilitent l'écoulement des produits agricoles et ou d'élevage et permettent aux populations de se ravitailler en denrées. Les loumas sont organisés à tour de rôle suivant la zone géographique (Nord et Sud), la région ou le département. Dans les départements de Matam et de Kanel (zone Nord) par exemple, les loumas fréquentés par les villages ciblés (Nabadji Siwol, Agname Thodèye, Orkadiéré, Bondji et Doundé) sont organisés du lundi au dimanche (cf. tableau n°1).

Tableau 1: Marchés hebdomadaires fréquentés par les villages ciblés

Villages	**Marchés hebdomadaires (« Loumas ») plus proches**	**Jours**	**Zone**
Thiancone Hiraye	Ourosogui	tous les jours	Nord
Hontorbé Kiriré I	Chef lieu CR Nabadji Siwol	Mercredi	Nord
Asndé Balla	Aganme Thiodèye	Mardi	Nord
Ouro Cebo	Orkadiéré	Dimanche	Nord
Ouro Silamaka	Louma Bonji	Jeudi	Nord
Boulone Samba Djiadi	Louma Doundé	Samedi	Nord
Boynguél Bamba Mbakanabé	Louma de Bala	Samedi	Sud
Gambi Koar Godioyél Bocar Yoro	Louma de Kothiatri	Lundi	Sud
Boulel Sinthiou Madina	Louma Gabou	Lundi	Sud
Samba Kolo	Goudiry et Kidira	tous les jours	Sud

CHANGEMENTS AU COURS DES 20 DERNIÈRES ANNÉES

Les changements enregistrés par les populations au cours des 20 dernières années sont présentés dans cette partie en mettant le focus sur les changements dans la taille et la mobilité de la population, dans les infrastructures, le profil global des moyens de subsistance, les activités génératrices de revenus, les pratiques agricoles, les pratiques d'élevage, les forêts et le régime des précipitations.

Changements dans la population

La totalité des populations des villages ciblés ont soulevé une augmentation considérable de la population au cours des 20 dernières années. En effet, selon ces populations, la mise en œuvre des programmes élargis de vaccination, les sensibilisations des relais communautaires sur l'importance des visites pré et post natales et des accouchements dans les structures sanitaires, la construction des infrastructures sanitaires ont considérablement contribué à réduire les mortalités infantiles et maternelles. La persistance des phénomènes des ménages polygames et des mariages précoces, l'arrivée des ressortissants Guinéens ou Maliens dans certaines localités (Koar,), l'émigration vers les pays de l'UE et les EU et dans une moindre mesure les

recommandations religieuses[1] ont également influé sur l'augmentation de la population. Il s'y ajoute que les femmes sont plus nombreuses que les hommes et que les jeunes représentent une proportion importante.

Ces résultats sur les changements de la taille et de la composition de la population confirment les tendances actuelles de la population sénégalaise constituée majoritairement de jeunes (54;7%) et avec une prédominance des personnes de sexe féminin (50,8%)[2].

Mobilité de la population

Les villages ciblés connaissent plusieurs formes de mobilités dont les plus répandues sont la migration saisonnière et l'émigration vers les autres pays. Ces formes de mobilités varient en fonction de la zone (Nord et Sud).

Les migrations saisonnières sont plus répondues dans la zone Nord. D'une part, elles se traduisent par déplacements des éleveurs vers le Ferlo, le Mali et la Mauritanie, à la recherche d'eau et de pâturages (Ouro Cebbo, Thiancone Hiraye et Hontorbé). D'autre part, on note également des déplacements des agriculteurs dans les champs du Walo (Kiriré 1).

Même si le contrôle est devenu plus stricte dans les frontières, les migrations vers les pays d'Europe (France et Italie), les USA et les pays de l'Afrique de l'Ouest sont très répandues dans la zone Nord (Ouro Silamaka, Boulone Samba Djadji, Kiriré 1).

Cependant, dans la zone Sud, ce phénomène a considérablement régressé au profit d'autres types déplacements. En effet, dans les villages de Gambi, Koar, Mbakanabé et Boynguél Bamba), les déplacements vers les grandes villes (Dakar et Tambacounda) et les mines de Kédougou prennent de plus en plus de l'ampleur. Les populations s'installent dans ces zones pour pratiquer les activités comme la maçonnerie, le petit commerce, le cirage et l'exploitation de l'or.

Dans le village Samba Kolo, les déplacements pour l'achat de produits (poissons, denrées alimentaires, etc.) en vue de ravitailler les ménages sont de plus en plus pratiqués par les commerçants.

L'arrivée de Baol Baol, Saloum Saloum, guinéens et maliens pour l'exploitation du bois et des produits forestiers (cueillette du pain de singe) a été soulignée par la plupart des populations de la zone Sud (Koar, Boynguél Bamba et Mbakhanabé).

Les populations imputent ces différentes formes de mobilités aux problèmes liés à l'emploi, et aux faibles rendements. Ces derniers sont dus à la rareté des pluies, à la mauvaise qualité du sol et à la présence d'insectes et d'oiseaux ravageurs.

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[1] Dans le village de Gambi par exemple, le Marabout Thierno Ahmed Tidiane Ba leur a convaincu d'abandonner les pratiques mystiques visant à réduire les natalités.

[2] ANSD, Rapport du 3ème recensement général de la population du Sénégal, 2002

Infrastructures dans les villages

Des changements considérables dans la structure et l'éclairage des bâtiments sont mentionnés par les populations de tous les villages ciblés. Ainsi, la plupart des habitations qui étaient en Banco et en pailles sont maintenant en dur. De même, les lampes tempêtes ont progressivement cédé la place aux panneaux solaires dans les maisons des émigrés. Pour les populations, ce changement est du au transfert d'argent des émigrés qui sont dans les autres pays (France, Italie, USA et pays de l'Afrique de l'Ouest) et les grandes villes (Dakar et Tambacounda, etc.).

En ce qui concerne l'alimentation en eau, les nappes des puits sont devenus plus profondes et les marres se tarissent rapidement dans la quasi-totalité des villages. Par contre dans le village de Asndé Balla, qui est sur la RN2, les puits, lampes tempêtes et panneaux solaires ont respectivement cédé la place au robinet et à l'électricité.

Les 20 dernières années sont marquées par l'installation d'écoles et d'infrastructures sanitaires dans la quasi-totalité des villages ciblées. Cependant les villages comme Boulone Samba Djadji et Kiriré 1 n'ont pas connu ce changement.

Profil globaux des moyens de subsistance

L'analyse des changements dans les profils globaux des populations révèle des différences notoires entre les villages de la zone Sud et ceux de la zone Nord.

Dans la zone Nord (Ouro Silamaka, Asndé Balla, Boulone Samba Djadji, Kiriré 1, Ouro Cebbo), les populations vivaient principalement de l'agriculture et secondairement de l'élevage. Cependant les profils globaux des moyens de subsistance révèle que les populations dépendent plus des revenus provenant de l'extérieur et de l'élevage que des revenus agricoles.

Néanmoins, la subsistance des populations de Thiancone Hiraye est assurée en grande partie par les transferts de fonds des émigrés. De même, les populations dépendent plus des revenus agricoles que ceux des autres activités comme l'élevage (Hontorbé), bien qu'il y ait des revenus tirés des activités de diversification (maraichers, commerce de poissons et de produits forestiers).

Dans la zone Sud (Gambi, Samba Kolo), l'agriculture est la première source de revenus et l'élevage vient en seconde position.

Les activités de diversification comme le maraichage, l'exploitation des produits forestiers et les activités artisanales (fabrication de briques en banco et de lits) constituent des sources de revenus très importantes pour les populations de Mbakhanabé.

Selon les populations, les principaux changements dans l'agriculture sont dus à l'augmentation des surfaces cultivées, la baisse des rendements (production est uniquement destinée à l'autoconsommation) et la baisse des revenus tirés de l'agriculture.

Les changements dans l'élevage sont la pratique de la transhumance, l'arrivée massive de troupeaux venant d'autres localités, dans la zone Sud, la baisse des ressources (eau et pâturage), la baisse des revenus tirés de l'élevage et la diminution du cheptel. La stratégie qui consiste à

vendre quelques têtes de bovins ou petits ruminants pour avoir des revenus immédiats est adoptée par les éleveurs.

Activités génératrices de revenus

Dans la zone Sud (Gambi, Koar, Mbakhanabé, Boynguél Bamba et Samba Kolo), les populations dépendent toujours de l'agriculture pour leur subsistance. Néanmoins, les sources de revenus sont très diversifiées (exploitation des ressources forestières, transferts de fonds, la vente de bétail notamment les bovins et les petits ruminants dans les marchés hebdomadaires). On constate également une augmentation des revenus tirés de l'exploitation des ressources forestières et une baisse des revenus tirés de l'agriculture (Gambi, Koar, Mbkhanabé, Boynguél Bamba). A Samba Kolo, la vente du bétail, de produits forestiers et dans une moindre mesure la vente de la production de mil ou de l'arachide sont les principaux sources de revenus.

Dans la zone Nord (Ouro Silamaka, Asndé Balla, Kiriré I Ouro Cebbo), la vente du bétail et l'émigration sont les principaux sources de revenus les plus stables et plus fiables. Ainsi, les revenus qui provenaient de l'agriculture ont connu une baisse significative tandis que les revenus tirés du transfert de fonds des émigrés se sont considérablement accrus. A Hontorbé par exemple, les sources de revenus ont fortement évolué, l'agriculture a progressivement laissé la place au maraichage (piment, chou, carotte, gombo et folléré) et à la vente d'animaux dans les marchés hebdomadaires de Nabadji Civol et de Taiba. A Ouro Silamaka, les activités génératrices de revenus étaient l'apanage des hommes. Mais depuis une dizaine d'années, les femmes mènent plus d'activités génératrices de revenus avec la vente de produits agricoles, de l'élevage et du bois mort.

Pratiques Agricoles

Les populations ont mentionné plusieurs changements dans les pratiques agricoles. Ainsi, dans tous les villages ciblés, les outils rudimentaires (daba, hilaire) ont progressivement laissé la place aux outils plus performants comme les semoirs, les charrues voire les tracteurs. Selon les populations, ce changement dans les pratiques agricoles a contribué à l'augmentation des terres cultivées.

Pour ce qui est de la gestion des terres cultivées, on note une réduction des surfaces en jachère (Gambi, Koar, Godioyel et Samba Kolo), dans la plupart des zones. Les villages de Ouro Cebbo, Mbakhanabé et de Boynguél Bamba ont même abandonné la pratique de la jachère. De même, les diguettes sont de plus en plus mis en place pour faciliter l'irrigation dans le village de Kiriré I. Dans la zone de Thiancone Hiraye, les populations ont abandonné les champs situés dans la zone des cuvettes au profit de ceux du Diéry.

Par ailleurs, dans le souci d'améliorer les rendements, les variétés de semences à cycles longs ont cédé la place aux semences à cycles courts (70 jours) dans certains villages. L'engrais est également utilisé pour accroitre les rendements (Samba Kolo).

Pratiques d'élevage

Les groupes de discussions de la quasi-totalité des villages ciblés en zone Nord ou Sud (Gambi, Koar, Godioyel, Mbakhanabé, Boynguél Bamba, Samba Kolo, Boulel Asndé Balla, Boulone Samba Diadji, Lordougo, Hontorbé, Ouro Cebbo, Thiancone Hiraye) ont fait ressortir deux stratégies qui sont de plus en développées par les Pasteurs, durant les 20 dernières années. La stratégie qui consiste à vendre le bétail pour subvenir à des besoins ponctuels et celle qui vise à saisir des opportunités comme les périodes de fêtes pour maximiser les profits. Les opportunités qu'offre le marché ont d'ailleurs favorisé l'émergence d'une catégorie d'acteurs, dénommée "*Téfankés*", spécialisée dans l'achat et la vente de bétail.

Le cheptel des exploitations familiales était dominé par les bovins. Cependant, depuis les 20 dernières années, le cheptel est dominé par les petits ruminants. Les populations imputent ces changements au fait que les petits ruminants sont plus résistants aux changements climatiques (Gambi, Sinthiou Madina, Kiriré 1, Thiancone Hiraye). Quant à la taille du cheptel, elle a considérablement augmenté durant les 20 dernières années (Godioyel, Mbakhanabé, Boynguél Bamba, Boulel, Sinthiou Madina, Samba Kolo, Ouro Silamaka, Asndé Balla, Kiriré 1, Ouro Cebbo). Selon ces populations, ce changement est dû l'augmentation du nombre d'émigrés qui ont beaucoup investi dans ce secteur. Dans certaines zones du Sud (Boynguél Bamba, Boulel, Ouro Cebbo), on note l'arrivée de nouvelles races de la Mauritanie qui sont venues s'ajouter à la race Ndama qui était dominante.

En ce qui concerne la conduite des troupeaux, la main d'œuvre était généralement familiale. Cependant elle est de plus en plus payante durant les 20 dernières années. Pour les populations, ce changement est du à la recrudescence du vol de bétail et l'émigration (Koar, Godioyel, Boynguél Bamba, Boulel, Sinthiou Madina, Asndé Balla, Boulone Samba Diadji et Lordougo, Kiriré 1, Ouro Cebbo).

Pour les petits ruminants, la stratégie qui consiste à remplacer les races qui ont un cycle de reproduction long par des espèces qui ont un cycle de reproduction très court est de plus en développées par les Populations de Hontorbé. Les 20 dernières années ont été également marquées par l'introduction de nouvelles espèces de moutons[3] (Koar, Gambi, Hontorbé). La recrudescence des épizooties dans certaines zones (Godioyel, et Boynguél Bamba) entraine des pertes énormes du cheptel.

Parcours

L'analyse du parcours fait ressortir plusieurs changements dans la qualité du parcours, la composition des espèces et la disponibilité saisonnière, qui différent selon la zone (Nord et Sud).

La totalité des zones du Sud (Boynguél Bamba, Gambi, Godioyél Bocar Yoro, Boulel, Mbakanabé, Koar, Sinthiou Madina et Samba Kolo) sont confrontées à une diminution du pâturage qui est due selon les populations à l'arrivée en masse de troupeaux venant des autres

[3] Bali Bali et Ladoume

régions, à la fréquence des feux de brousse durant la saison sèche, à la baisse des précipitations et la venue des exploitants forestiers clandestins. Pour ce qui est de la qualité du parcours, les populations de cette zone (Gambi, Koar, Godioyél Bocar Yoro, Boynguél Bamba, Samba Kolo et Boulel) ont remarqué la disparition de certaines espèces très prisées par les animaux (Yalalo et Thiélale). Selon ces populations, les feux de brousse et la baisse des précipitations sont les principales causes de ce changement. D'autres (Sinthiou Madina) ont même mentionné l'apparition d'espèces venant du Fouta et qui ne sont pas très prisés par les animaux (Diandiali et Loubbar).

En outre, la pratique de la transhumance à la recherche de pâturages fait la spécificité de certains villages de la zone Nord (Ouro Silamaka, Asndé Bala, Thiancone Hiraye, Ouro Cebbo). Cette stratégie est développée par la population pour faire face à la diminution du pâturage. En ce qui concerne la qualité du parcours, la baisse des précipitations et l'augmentation de la taille du cheptel ont entrainé la disparition de certaines espèces herbacées.

Forêts

La configuration des forêts vue par les populations laisse apparaitre des différences notoires entre la zone Sud et Nord. Dans les villages situés dans la zone Sud, les forêts qui étaient très denses sont devenues moins touffues. La disparition de certaines espèces d'arbres comme les bambous, les rôniers, les "*Kél*", etc. sont mentionnées par ces populations. Les causes perçues par ces populations sont les abatages clandestins des arbres, les feux de brousse, l'exploitation du bois destiné à faire du charbon de bois, les agabés venus du Fouta et les maliens.

Par contre, à l'exception de Boulone Samba Djadji, les villages de la zone Nord sont caractérisés par la disparition des ressources forestières. Ces changements sont dus à la sécheresse et la déforestation. Ces populations ont également souligné la présence d'espèces comme les jujubiers, les balanites qui, selon elles, sont plus résistants à la sécheresse. Ainsi, les ressources forestières sont toujours présentes à Boulone Samba Diadji et permettent aux populations d'avoir de la paille pour les toits des cases, du bois pour la fabrication des hangars et des clôtures.

Régime des Précipitations

Le volume des précipitations s'est considérablement réduit dans tous les villages ciblés. Il s y ajoute une diminution de la durée de la saison des pluies qui est passé de 6 à 4 mois dans villages situés dans la zone Sud et de 6 à 2 ou 3 mois dans ceux de la zone Nord. Ces populations imputent ces changements à la déforestation et à la volonté divine.

CHANGEMENTS DANS LES TYPES ET LA GESTION DES CULTURES AU COURS DES 20 DERNIERES ANNEES

Changements des cinq premières cultures

La classification des cinq premières cultures varie en fonction du village et même selon que le groupe est composé d'hommes ou de femmes. Néanmoins, on peut déceler quelques similitudes entre les villages d'une même zone.

Dans les villages situés dans la zone Sud et Boulone Samba Diadji, les Mil et Maïs sont les deux premières cultures, suivi du sorgho et de l'arachide qui occupent les 3èmes et 4èmes places. Suivant le village, l'oseille, le niébé, le gombo et le riz occupent la 5ème place. Dans les villages situés dans la zone Nord, le mil, le sorgho, le mais, la pastèque, l'arachide, le niébé, l'oseille et le gombo sont les principales cultures. Cependant, il est difficile de faire une classification uniforme des principales cultures.

Dans tous les villages ciblés, les populations ont, d'une part, mentionné l'augmentation des superficies cultivées qui est due à l'augmentation de la main d'œuvre et aux matériels agricoles adaptés. D'autre part la baisse des rendements à la corde est due à la baisse de la fertilité des sols et la baisse des précipitations l'abandon de la jachère. La spécificité des villages situés dans la zone Nord est la présence d'insectes et d'oiseaux ravageurs, les périls acridiens et le coût élevé des intrants (semences, engrais) de certaines spéculations comme l'arachide qui réduisent considérablement les rendements.

Spéculations qui ne sont plus cultivées

La culture du coton a été abandonnée par certains villages situés dans la zone Sud (Gambi, Koar, Godioyél, Mbakhanabé et Boynguél Bamba) parce qu'elle n'est pas rentable pour le producteur. Ainsi, selon ces populations, les récoltes ne permettent pas de rembourser les dettes à l'égard des créanciers comme la Sodefitex qui leur octroie les intrants à crédit. Par contre, dans les villages situés dans la zone Nord (Asndé Bala, Kiriré 1, Thancone Hiaye et Hontorbé), la faible pluviométrie explique l'abandon de la culture du coton et de l'indigo.

D'autres spéculations comme le manioc, melon ne sont plus cultivés dans les villages de Koar et Gambi à cause de la divagation des phacochères qui détruisent les récoltes.

Les variétés de mil (sagno) et de sorgho (féla et niédico) à cycles courts, le riz et le fonio ne sont plus cultivées à cause de la baisse de la pluviométrie, des insectes et des oiseaux ravageurs et du péril acridien.

Introduction de nouvelles spéculations

L'introduction des cultures maraichères très diversifiées (aubergine doux et amère, salade, carotte, chou, navet, piment, concombre, courge, tomate oignon) dans les tous les villages ciblés a été noté par les populations. Ces dernières considèrent que les cultures maraichères sont très rentables et contribuent à accroitre les revenus et la sécurité alimentaire des exploitations agricoles.

Les spéculations comme le voandzou[4] et le taro[5], les variétés de mil et sorgho à cycle court sont introduites dans certaines zones pour faire face aux changements climatiques de manière générale et à la baisse de la pluviométrie en particulier.

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[4] "*Gadianga*" en langues locales

[5] "*Diabaré*" en langues locales

Changements dans la gestion des cultures

Plusieurs changements sont notés dans la gestion des cultures comme le mil, le mais, le sorgho et l'arachide.

Dans tous les villages, les semoirs à traction animale et les charrues sont introduites pour les cultures comme le mil, le mais, le sorgho et l'arachide. De même, ces cultures bénéficient d'une augmentation de la main d'œuvre qui est due à l'augmentation de la population. Face à la baisse des rendements, deux stratégies d'adaptation sont retenues par les populations des villages situés dans la zone Sud: l'utilisation des bouses de vaches et l'augmentation des surfaces cultivées. Les difficultés d'accès à la terre ont favorisé l'abandon de la jachère dans certains villages (Giodioyél et Boulel).

Pour faire face à la baisse de pluviométrie, les variétés de céréales sèches (mil, sorgho et mais) et de niébé à cycle court ont été introduites dans certains villages (Sinthiou Madina, Mbakhanabé, Samba Kolo, Thiancone Hiraye).

La stratégie qui consiste à remplacer la culture du mil et du sorgho par celle du maïs, pour faire face aux attaques des oiseaux ravageurs et aux périls acridiens, a été une stratégie spécifique aux populations des villages situés dans la zone Nord (Kiriré 1, Ouro Cebbo, Boulone Samba Diadji).

La pratique de la double culture du maïs (culture pluviale et de décrue) est également une spécificité du village de Ouro Silamaka. En effet, l'installation des refugiés mauritaniens, vers les années 1989, a été à l'origine de cette pratique.

CHANGEMENTS DANS LA GESTION ET LES PRATIQUES D'ELEVAGE

Les changements notés dans la gestion et les pratiques d'élevage sont abordés en mettant l'accent sur la composition du troupeau, le pâturage durant la saison sèche et la saison pluvieuse; la transhumance, la conduite et la gestion du troupeau, l'alimentation du bétail, la santé animale, l'abreuvage des animaux, la commercialisation des produits d'élevage.

Composition du troupeau

La composition du troupeau est toujours la même. On retrouve les bovins, ovins, caprins, équins, asins et volailles.

Pour les bovins, ovins et caprins, il y a toujours la présence la présence de la race "*Ndama*" dans la totalité des villages situés de la zone Sud. Cependant, des métissages avec les races venant du Fouta et de la Mauritanie sont mentionnés par les populations. Selon ces derniers, les raisons de ces métissages sont la faible productivité de la race "*Ndama*". Pour pallier à la faible productivité de cette race, l'introduction de nouvelles espèces plus productives, à travers le Programme d'insémination artificielle, a été initiée. Cependant, selon ces populations, cette tentative a échoué pour des raisons génétiques.

Dans les villages situés dans la zone Nord, quelques changements sont notés dans la composition des espèces. Dans les villages de Hontorbé, Kirirré 1 et Asndé Balla, les races locales d'ovins (couleur rougeâtre) ont été progressivement remplacées par les moutons de

couleur blanche ("Bali Bali" et "Ladoume") qui sont plus faciles à commercialiser. Pour les caprins, on note l'introduction de la race Ndama dans le village de Hontorbé, qui selon les populations, s'adapte plus facilement aux changements climatiques.

Pâturage en saisons sèche et pluvieuse

La diminution du pâturage a été un changement majeur dans tous les villages situés dans la zone Sud et Boulone Samba Diadji. Les causes, perçues par les populations, sont la fréquence des feux de brousse, la surexploitation par le bétail venant du Fouta et de la Mauritanie et les coupes sauvages des arbres par ces transhumants.

A l'exception de Boulone Samba Diadji, le pâturage n'est disponible qu'en saison des pluies qui dure deux à trois mois, dans les villages situés dans la zone Nord. Cette situation favorise la transhumance par les pasteurs.

Transhumance

La quasi-totalité des villages du Sud ne pratiquent pas la transhumance (Gambi, Koar, Godioyél, Mbakhanabé, Samba Kolo et Boulel). Cependant quelques déplacements des troupeaux à la recherche de pâturage, vers les villages environnants et parfois vers le Fouta, sont enregistrés durant la saison sèche (Boynguél Bamba et Sinthiou Madina). Les pasteurs des villages du Sud imputent divers changements (baisse pâturage, feux de brousses, apparition d'espèces non appétées par le batail, etc.) à l'arrivée de troupeaux des Agabés venant du Fouta et des pasteurs de la Mauritanie.

Comme mentionné dans la partie précédente, la spécificité des villages situés dans la zone Nord (Asndé Bala, Kiriré 1, Thiancone Hiaye, Ouro Cebbo, Ouro Silamaka et Hontorbé) est la pratique de la transhumance. En effet, les destinations qui étaient les villages environnants, sont aujourd'hui les régions au Sud du pays et les pays limitrophes (Tambacounda, Kédougou, Ranérou, Mali et Mauritanie). Ces changements sont dus à l'augmentation des troupeaux et les nouveaux campements qui sont installés dans des zones plus proches.

Conduite et gestion du troupeau

Le bétail qui était géré par une main d'œuvre familiale est aujourd'hui géré par un berger privé qui reçoit un salaire mensuel. La gestion peut être individuelle[6] ou collective[7]. Les causes, perçues par les populations, est la recrudescence du vol de bétail et l'émigration (Koar, Godioyel, Boynguél Bamba, Boulel, Sinthiou Madina, Asndé Balla, Boulone Samba Diadji et Lordougo, Kiriré 1, Ouro Cebbo)

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[6] C'est le cas où le berger gère les troupeaux d'une seule famille

[7] Dans ce cas, le berger gère les troupeaux de plusieurs familles

Utilisation résidus et récoltes et achat intrants

Les résidus de récoltes sont toujours utilisés par les agro-pasteurs. Cependant, ils sont insuffisants par rapport à la taille des troupeaux. Pour pallier à cette insuffisance, les feuilles d'arbres sont de plus en plus utilisées. De même, pour faire face à la raréfaction du pâturage et des résidus de récoltes, les pasteurs, qui disposent de moyens financiers, achètent souvent l'aliment de bétail fabriqué par les industriels[8]. Le prix du sac de 40 Kg varie entre 8 500 et 10 000 FCFA. Du fait des différences sur le parcours, le recours à ces aliments de bétail industriel est plus fréquent dans les villages situés dans la zone Nord que ceux situés dans la zone Sud.

Santé animale

Les soins vétérinaires qui étaient assurés par les services étatiques sont aujourd'hui gérés par les vétérinaires privés. La vaccination qui était gratuite est devenue payante avec le désengagement de l'Etat. Ce changement a favorisé l'arrivée des vétérinaires privés. Même si ces vaccinations ont favorisé la disparition de certaines pathologies, la pasteurellose, le botulisme, la clavelée semblent endémiques dans ces zones.

Ressources en eau

L'abreuvage des animaux qui était assuré par les mares qui entourent les villages est aujourd'hui assuré par les puits et forages du village ou des autres villages voisins et même des bornes fontaine (Asndé Balla ET Hontorbé). Les causes perçues par les populations sont la baisse de la pluviométrie qui entraine le tarissement des marres.

Commercialisation du bétail

Pour des raisons culturelles, la vente de bétail n'était pas pratiquée par les pasteurs. Cependant, depuis une vingtaine d'années, deux stratégies sont de plus en développées par les pasteurs. La stratégie qui consiste à brader le bétail durant les périodes de soudures, pour subvenir à des besoins ponctuels et celle qui vise à saisir des opportunités comme les périodes de fêtes pour maximiser les profits. Les opportunités qu'offre le marché ont d'ailleurs favorisé l'accroissement des "*Téfankés*", spécialisée dans l'achat et la vente de bétail. Ainsi, la vente du bétail est devenue une source de revenus non négligeable pour les ménages. Les espèces les plus commercialisées sont les ovins, puis viennent les bovins et les caprins.

CHANGEMENTS IMPORTANTS DES MOYENS DE SUBSISTANCE DANS L'AGRICULTURE OU L'ELEVAGE

Dans les villages situés dans la zone Sud et à Ouro Cebbo, certains ménages s'adonnent plus à l'élevage qu'à l'agriculture. Ainsi, les ménages ayant un membre immigré ont acheté de nouvelles

[8] La composition de cet aliment varie en fonction des matières premières disponibles: son de blé, mais, tourteau d'arachide, de coton et de soja, coque d'arachide, Mélasse, sorgho, farine de poissons, Carbonate de Ca, sels et premix.

têtes de bétail. Les raisons de ce choix sont la forte rentabilité de l'activité d'élevage mais aussi les difficultés liées à l'activité agricole (baisse pluviométrie, appauvrissement des terres, faible production, etc.). D'autres ménages s'adonnent plus à l'agriculture qu'à l'élevage en achetant des outils modernes leur permettant d'augmenter les surfaces cultivées. L'autoconsommation, l'utilisation des résidus pour le bétail, la commercialisation des excédents (Koar) sont les principales raisons de ce choix. Les difficultés de l'activité d'élevage, comme le manque de pâturage, d'eau et la recrudescence des pathologies, justifient également ce choix.

Dans les villages de Samba Kolo et Ouro Silamaka, l'agriculture est la principale activité car elle assure l'autoconsommation des ménages.

L'élevage est la principale activité dans les villages de Ouro Cebbo, Asndé Balla, Boulone Samba Diadji et à Hontorbé. Les populations considèrent que l'activité d'élevage est très rentable et rend les populations moins vulnérables.

PRINCIPALES CONTRAINTES

Contraintes du secteur agricole

Les principales contraintes qui limitent l'activité agricole dans les zones sont d'ordres climatiques et techniques. Ces contraintes sont classées, comme suit:

- baisse ou variabilité pluviométrique
- baisse de la fertilité des sols
- faibles moyens de production (engrais, semences et vétusté du matériel agricole)
- invasion des insectes, parasites et oiseaux ravageurs

En premier lieu, les systèmes de production des zones ciblés sont tributaires de la pluviométrie qui se traduit par une variabilité de sa répartition dans le temps et dans l'espace. Selon les populations, cette situation est à l'origine de la baisse de la production céréalière et par conséquent de l'insécurité alimentaire. Pour faire face à la baisse de la pluviométrie, les populations préconisent la construction de forages et de bassins de rétention. Elles proposent également de mettre à disposition des producteurs des variétés de semences à cycle court pour toutes les spéculations.

En deuxième lieu, la baisse de la fertilité des sols entraine l'extension des cultures, la diminution des rendements. Pour faire face à cette contrainte, une meilleure disponibilité des moyens de production (engrais, semences et vétusté du matériel agricole) a été préconisée. Hors, la rareté et la cherté des semences, le coût élevé de l'engrais et la vétusté du matériel agricole constituent des contraintes non négligeables pour ce secteur. Ces contraintes conduisent à l'extension des terres de cultures, la diminution des rendements et l'insuffisance des réserves de céréales. Les populations prônent la mise à dispositions des intrants subventionnés et la subvention du matériel agricole.

Enfin, l'invasion des insectes, parasites et oiseaux ravageurs est également considérée comme une contrainte de l'activité agricole. Selon les populations, ces ravageurs entrainent la destruction des récoltes. Pour faire face à cela, elles préconisent l'accessibilité des pesticides en quantités et en termes de prix. Elles proposent également l'intervention de la direction de protection des végétaux (DPV) pour faire face aux périls acridiens.

Contraintes du secteur de l'élevage

Pour le secteur de l'élevage, les contraintes sont essentiellement liées aux ressources naturelles (sol, eau, fourrage) et à la variabilité climatique. Les principales contraintes décelées sont :

- Les épizooties
- Le vol de bétail
- La diminution des parcours de bétail
- Les problèmes d'abreuvement (eau)

La fréquence pathologies animales est l'une des principales contraintes de l'élevage. Ces épizooties sont dues à la persistance de la sécheresse dans les zones du projet. Selon les populations, l'organisation périodique des campagnes de vaccination et la mise à disposition d'un vétérinaire pour la vaccination et le traitement du bétail peut régler les problèmes des épizooties.

Le vol de bétail, du essentiellement au manque de sécurité du système de production animale, est la deuxième contrainte soulignée par les populations. Cette contrainte a des effets négatifs sur les effectifs du cheptel. Pour éradiquer ce phénomène, les populations proposent des mesures répressives plus strictes.

L'élevage est tributaire des ressources naturelles comme l'eau, le pâturage et les terres. Avec la variabilité climatique qui a pour corollaire le déficit pluviométrique et l'extension des terres de culture, il est confronté à des contraintes telles que la réduction des parcours de bétail, la rareté ou la disparition des espèces appétées et la réduction des ressources en eau pour l'abreuvage des animaux. Comme dans le cas précédent, cette contrainte influe négativement sur les effectifs et la productivité du cheptel. La transhumance est une stratégie adoptée par les éleveurs des villages situés dans la zone Nord pour faire face aux contraintes liées aux ressources naturelles comme l'eau, le pâturage et les parcours de bétail. Ces éleveurs proposent aussi la subvention de l'aliment de bétail industriel.

CONCLUSION

L'analyse des stratégies d'adaptation autonomes a été faite en mettant le focus sur les caractéristiques des moyens de subsistance, les transformations de ces moyens de subsistance et les changements spécifiques aux types et à la gestion des cultures et aux pratiques et à la gestion de l'élevage.

Ainsi, les moyens de subsistance des zones ciblées sont très diversifiés. Il s'agit principalement des activités agricoles, des activités pastorales, de l'exploitation des ressources naturelles, du commerce des produits agricoles, d'élevage, forestiers. Ces moyens de subsistance font face aux effets négatifs de la variabilité climatique qui prend de plus en plus de l'ampleur dans ces zones. Cette situation rend les populations de plus en plus vulnérables. Cependant, plusieurs stratégies qui tiennent compte des ressources dont disposent ces zones et des mutations de l'environnement sont développées par les populations. En effet, l'analyse a permis de faire ressortir plusieurs stratégies d'adaptation autonomes qui prennent en compte les marges de manœuvre dont dispose les pasteurs et les agriculteurs pour réduire leur vulnérabilité.

Les stratégies développées par les pasteurs visent à réduire leurs vulnérabilités par rapport à la variabilité climatique. Ainsi, elles visent non seulement à faire face à la diminution du pâturage et à la baisse de la pluviométrie mais aussi à augmenter les revenus tirés de cette activité. D'une part, pour faire face à la diminution du pâturage et à la baisse de la pluviométrie, la

transhumance est pratiquée par la population de certains villages de la zone Nord (Ouro Silamaka, Asndé Bala, Thiancone Hiraye, Ouro Cebbo). D'autre part, en vue d'augmenter leurs revenus, les pasteurs ont développés quatre stratégies. La première stratégie qui consiste à vendre le bétail pour subvenir à des besoins ponctuels. La deuxième consiste à saisir les opportunités comme les périodes de fêtes pour vendre le bétail en vue maximiser les profits. L'introduction de nouvelles espèces d'ovins est la troisième stratégie développée. Ainsi, dans les villages de Hontorbé, Kirirré 1 et Asndé Balla, les ovins de couleur rougeâtre ont été progressivement remplacé par les moutons de couleur blanche, qui sont plus rentables. Enfin, la stratégie qui consiste à élever plus de petits ruminants (ovins et caprins) que de bovins est adoptées par les pasteurs[9] des villages de Gambi, Sinthiou Madina, Kiriré 1 et Thiancone Hiraye.

Pour l'agriculture, plusieurs les stratégies, visant à faire face à la baisse de la pluviométrie, à la baisse de la fertilité des sols et à augmenter les revenus, ont été développées par les populations. Pour faire face à la baisse de pluviométrie, les variétés anciennes de cultures céréalières (mil, sorgho et mais) tardives et de haricot sont remplacées par les variétés hâtives de céréales sèches dans certains villages (Sinthiou Madina, Mbakhanabé, Samba Kolo, Thiancone Hiraye). La pratique de la double culture du Mais (culture pluviale et de décrue) est également une spécificité du village de Ouro Silamaka. La stratégie qui consiste à remplacer la culture du Mil et Sorgho par celle du Mais, pour faire face aux attaques des oiseaux ravageurs et aux périls acridiens, a été une stratégie spécifique aux populations des villages situés dans la zone Nord (Kiriré 1, Ouro Cebbo, Boulone Samba Diadji). En vue d'accroitre les revenus des exploitations agricoles, la stratégie qui consiste à développer plus de cultures maraichères (aubergine doux et amère, salade, carotte, chou, navet, piment, concombre, courge, tomate oignon) a été adopté par les populations de les tous les villages ciblés. Les variétés hâtives des spéculations comme le voandzou et le taro sont également introduites dans certaines zones pour faire face aux changements climatiques de manière générale et à la baisse de la pluviométrie en particulier.

Par ailleurs, la migration contribue de façon considérable à la réduction de la vulnérabilité des exploitations agricoles et pastorales. Ainsi, les revenus tirés de l'émigration vers les pays d'Europe (France et Italie), les USA et les pays de l'Afrique de l'Ouest, très répandues dans la zone Nord (Ouro Silamaka, Boulone Samba Djadji, Kiriré 1), permettent aux populations d'investir dans les activités pastorales qui, selon les populations, sont très rentables. De même, les déplacements vers certaines grandes villes du Sénégal (Dakar et Tambacounda) et les mines de Kédougou constituent des sources de revenus non négligeables pour les populations de Gambi, Koar, Mbakanabé et Boynguél Bamba.

Les données sur les focus group ne permettent de nous prononcer de manière scientifique sur l'hypothèse[10] de recherche dans la mesure où l'importance de l'agriculture et de l'élevage varie en fonction de la zone, du village et du même du ménage. Néanmoins, certaines informations pourraient permettre de confirmer cette hypothèse. Ainsi, dans la zone Nord, qui est plus affectée par les changements climatiques (baisse de la pluviométrie, disparition des ressources

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[9] Selon les populations les petits ruminants sont plus résistants aux changements climatiques que les bovins.

[10] "*Les ménages avec des moyens de subsistance qui comprennent l'élevage sont moins vulnérables aux changements climatiques que les ménages dont les revenus dépendent principalement des cultures agricoles*".

forestières), la principale activité, de la quasi-totalité des villages (Ouro Cebbo, Asndé Balla, Boulone Samba Diadji et Hontorbé), est l'élevage.

ANNEXES

Guide d'entretien Focus groupe

VULNERABILITE AU CHANGEMENT CLIMATIQUE DANS L'EST DU SENEGAL

Plan du rapport du focus groupe

Introduction

Département :

Village :

Groupe :

Date :

Focus dirigé par :

Zone :

1. CARACTERISTIQUES DES MOYENS DE SUBSISTANCE (ce sont des descriptions générales qui permettent une classification des moyens de subsistance, quelques idées du niveau de la technologie, de la variabilité saisonnière dans l'utilisation des ressources et des stratégies de commercialisation)

A. Activités agricoles: décrire les principales activités agricoles, y compris les principales cultures qui sont cultivées, le calendrier saisonnier des activités (la préparation du sol, le semis, le désherbage, la lutte contre les parasites, la récolte, le traitement après la récolte et le stockage, etc.), les principales technologies (main d'œuvre, utilisation d'engrais, etc.), et la commercialisation de ces produits (qui sont vendus, qui sont gardés pour la consommation, etc.).

B. Activités pastorales : décrire la façon dont les animaux sont intégrés dans le système de subsistance (l'activité principale, une activité complémentaire, etc.), quels espèces d'animaux sont les plus courants, les activités saisonnières dans les soins à ces animaux (saison sèche, saison des pluies, etc.), les intrants pour l'alimentation, les soins vétérinaires, la commercialisation des animaux et des produits animaux (chaque année, uniquement en cas de besoin, ou vendus, etc.).

C. Gestion des ressources: Décrivez comment les ménages ont accès à la terre et aux pâturages, où l'eau est obtenue en saison sèche et en saison de pluies, comment les gens utilisent les produits forestiers pour le bois de chauffage (et la vente de bois de chauffage ou du charbon), la construction, le logement, l'artisanat, etc.

D. Mobilité des villages: Décrire les modes d'émigration, qui va où et quand, et si les transferts de fonds sont une partie importante de l'économie du village. Inclure les enfants qui quittent le village pour étudier : où et pour quel niveau de scolarité.

E. Transhumance: Décrivez tous les mouvements des gens vers les pâturages saisonniers, qui y vont, comment ils déterminent où aller, quand ils y vont.

F. Vulnérabilités perçues: décrire l'endroit où les gens perçoivent leurs principales difficultés et défis de l'agriculture, de la gestion de l'élevage, de l'accès à la terre et à l'eau, de l'accès aux revenus et aux marchés, etc.

G. Liens externes: décrire la présence générale des services publics (santé, éducation, vulgarisation rurale, électrification rurale, etc.), les ONG actives dans le village, des liens religieux et des groupes du secteur privé (agents de commercialisation, l'industrie locale, etc.

2. CHANGEMENTS AU COURS DES 20 DERNIÈRES ANNÉES : décrire les changements et les causes des changements perçus dans les catégories suivantes. Cette conversation commence habituellement par un événement de référence (une sécheresse, l'élection d'un président, la déflation de la monnaie, la guerre ou la paix, etc.), mais le délai doit être établi de façon uniforme dans la session du FGD. Pour chaque catégorie, l'animateur présente le sujet et suscite des discussions sur les changements au cours de cette période et les causes de ces changements.

A. Changements dans la population : Décrire les changements dans le nombre de personnes dans le village, le nombre de ménages, l'équilibre entre les sexes, la structure d'âge, etc. Ensuite, les causes perçues des changements sont décrites.

B. Mobilité de la population: Décrire les changements dans la façon dont les gens se déplacent à l'intérieur et hors du village, les niveaux d'émigration, la migration saisonnière, etc. Décrire les causes perçues de ces changements.

C. Infrastructure des villages : Décrire les changements dans la façon dont le village "ressemble", les types de maisons et bâtiments, l'électricité, les puits d'eau, les routes, les marchés, etc. Décrire les causes perçues de ces changements.

D. Profils globaux des moyens de subsistance : décrire les changements dans la façon dont les ménages obtiennent les moyens avec lesquels ils vivent, plus ou moins agricoles, plus ou moins de l'élevage, plus de dépendance sur les revenus non agricoles, etc. Décrire les causes de ces changements.

E. Activités génératrices de revenus: décrire les changements dans les sources de revenus, types de revenus, dépendance de revenu hors ferme, quelle personne (mâle/femelle) s'engage dans des activités génératrices de revenus, les sources les plus stables et les plus fiables de revenus, etc. Décrire les causes perçues de ces changements.

F. Pratiques agricoles : décrire les changements dans les pratiques agricoles, les technologies, les mélanges de cultures, la gestion des sols (diguettes, etc.), les rotations et les jachères, etc. Décrire les causes perçues de ces changements.

H. Pratiques d'Elevage/ Pastoralisme : décrire les changements dans la composition du troupeau, la gestion du troupeau, la taille du troupeau, les schémas de commercialisation et la gestion des parcours. Décrire les causes perçues de ces changements.

I. Parcours : décrire les changements dans la «qualité» du parcours, la composition des espèces, la disponibilité saisonnière, etc. Décrire les causes perçues de ces changements.

J. Forêts : décrire les changements dans la disponibilité des bois et forêts, les changements dans la composition des espèces et de l'accès. Décrire les causes perçues de ces changements.

K. Régime des précipitations: Décrire les changements perçus dans les précipitations, les changements dans la saisonnalité, les débuts et la durée, la variabilité intra saisonnière, etc. Décrire les causes perçues de ces changements.

3. CHANGEMENTS DANS LES RÉGIMES DE CULTURES OVER 20 DERNIÈRES ANNÉES : Cette section décrit les modifications détaillées dans les modes de culture. Elle demande les descriptions d'une culture à l'autre des changements pour les 5 cultures primaires citées par le groupe, les changements ces cultures ont subi en termes de quantité cultivée et type de sol où chacune est cultivée. Les raisons de ces changements sont également demandées.

A. Culture # 1: changements et raisons des changements.

B. Culture # 2: changements et raisons des changements.

C. Culture # 3: changements et raisons des changements.

D. Culture # 4: changements et raisons des changements.

G. Culture # 5: changements et raisons des changements.

F. Dressez la liste des cultures qui étaient autrefois cultivées et qui ne le sont plus maintenant et décrire les raisons de ces changements.

H. Faire la liste des nouveaux produits cultivés depuis 20 ans et décrire les raisons de ces changements.

I.

4. CHANGEMENTS DANS LA GESTION DES CULTURES : Pour les trois premières récoltes (liste ci-dessus), décrire les changements qui se sont produits au cours des 20 dernières années dans les pratiques de plantation, le travail utilisé, les intrants, le stockage et la commercialisation. Décrire ensuite les raisons de ces changements.

A. Culture # 1 [petit mil] : Décrire les changements et les raisons de ces changements.

i. Changement 1

ii. Changement 2

iii. Changement 3

B. Culture # 2 [le maïs] : Décrire les changements et les raisons de ces changements.

i. Changement 1

ii. Changement 2

iii. Changement 3

C. Culture # 3 [le sorgho] : Décrire les changements et les raisons ces changements.

i. Changement 1

ii. Changement 2

iii. Changement 3

5. CHANGEMENTS DANS LES PRATIQUES D'ELEVAGE : Décrire les changements dans la gestion et les pratiques de l'élevage au cours des 20 dernières années pour chaque type de bétail (bovins, moutons et chèvres, chameaux, etc.). Décrire ensuite les raisons de ces changements.

A. Décrire les changements dans les espèces, la composition du troupeau et les races et ensuite les raisons de ces changements.

B. Décrire les changements dans les paramètres régionaux de pâturage pendant la saison sèche et la saison pluvieuse et les raisons de ces changements.

C. Décrire les changements dans les routes de transhumance et expliquer les raisons de ces changements.

E. Décrire les changements dans les habitudes de travail des ménages pour la gestion du bétail et expliquer les raisons de ces changements.

F. Décrire les changements dans l'utilisation des aliments, les résidus de récolte, couper et transporter le foin et expliquer les raisons de ces changements.

F. Décrire les changements dans l'utilisation des intrants achetés, les types et les montants et expliquer les raisons de ces changements.

G. Décrire les changements dans les pratiques vétérinaires et de santé animale et expliquer les raisons de ces changements.

J. Décrire les changements dans la gestion des puits et autres sources d'eau pour les troupeaux du bétail et expliquer les raisons de ces changements.

K. Décrire les changements dans les pratiques de commercialisation pour les animaux et les pratiques d'animaux et expliquer les raisons de ces changements.

L. Décrire d'autres changements dans la gestion du troupeau et les raisons de ces changements.

6. CHANGEMENTS IMPORTANTS DES MOYENS DE SUBSISTANCE DANS L'AGRICULTURE OU L'ELEVAGE : décrire les principales décisions du ménage au cours des 20 dernières années pour passer à plus d'agriculture ou à plus de bétail.

A. Dans ce cas, expliquer pourquoi ce ménage a commencé à élever plus d'animaux et à développer un peu plus de cultures.

D. Dans ce cas, expliquer pourquoi ce ménage a commencé à développer plus de cultures et à élever plus d'animaux.

7. Principales contraintes : Décrire quels sont les principaux obstacles qui empêchent les gens de développer davantage de cultures ou d'élever plus d'animaux et ce qui peut être fait.

A. Contrainte #1 et ce qui peut être fait.

E. Contrainte #2 et ce qui peut être fait.

F. Contrainte #3 et ce qui peut être fait

NOTES ET REMARQUES SPECIALES :

ANNEX V. ANALYSIS OF HOUSEHOLD SURVEY

BUREAU D'ANALYSES MACRO-ÉCONOMIQUES

ETUDE ARCC

Évaluation de la vulnérabilité du Sénégal au changement climatique et analyse des options

STRATÉGIES D'ADAPTATION AUTONOMES

Analysis of Household Survey

Summary

The agro-ecological zones of Senegal are not spared from food insecurity and the impacts of climate change, although vulnerability to these threats varies across the country. For the Senegal River Valley, the strategies implemented by local populations remain insufficient, and the actions undertaken by the state, as well as the projects and programs of its partners, do not seem to be coordinated and centered on the needs of the public. Individual strategies dominate and are driven by the will to produce agricultural products and livestock. Both farmers and herders, however, have little motivation, and the lion's share of household income comes from emigration. The food security derived from farming varies from one zone to another, within the same zone, and by farm. The lean period falls within the months of July and August. The creation of grain stores concerns half the households of our sample, and primarily consists of corn, millet, and sorghum.

While these grains form the foundation of the diet across the study zone, the farming of these crops is more significant in the southern zone than in the north. The area of land farmed is greater in the south zone. Generally, fields cultivated by women are smaller than those farmed by men. Women's small plots, located in Diery, are more exposed to climate hazards than in other locations.

Climate change is a reality all across the Senegal River Valley. It spurs the development of individual and collective autonomous strategies, as well as exogenous strategies by the communities, as those affected attempt to deal with its consequences. This situation requires the development of a greater number of specific accompanying measures, projects, and programs that take into account the culture and needs of local populations as welll as the strategies they have already developed to cope with climate change.

RÉSUMÉ

Les zones agro écologiques du Sénégal ne sont pas épargnées par le changement climatique et l'insécurité alimentaire, bien que ces deux paramètres varient selon la zone considérée. Pour la Vallée du fleuve Sénégal, les stratégies mises en place par les populations locales ne sont pas toujours appropriées. Les actions entreprises dans ce sens par l'Etat et les projets et programmes ne semblent pas être coordonnés et centrés sur les besoins des populations. Peu d'acteurs sont au courant des objectifs et des résultats attendus de ces actions. Les stratégies individuelles dominent et sont imposées par la volonté de produire (produits agricoles et d'élevage) et de préserver le cheptel qui est essentiellement composé de petits ruminants et de bovins de races locales. Les initiatives entre paysans d'une part et éleveurs d'autre part sont faibles. La majeure partie du revenu des ménages proviennent de l'émigration. La sécurité alimentaire des exploitations agricoles varie en fonction des zones et dans une même zone, en fonction des exploitations. Les périodes de soudure coïncident avec les mois de Juillet et d'Aout. La constitution de stocks de semence concerne la moitié des exploitations de notre échantillon et touchent plus le maïs, le mil et le sorgho. Cette constitution de stock de semence est plus réelle dans la zone sud que dans la zone nord. Les céréales constituent l'aliment de base au nord comme au sud de la zone de l'étude.

Les superficies sont plus importantes dans la zone sud et d'une manière générale celles cultivées par les femmes sont faibles comparées à celles de hommes Les parcelles des femmes, localisées au niveau du Diéry, sont plus exposé aux aléas climatiques.

Le changement climatique, étant une réalité tout au long de la vallée du fleuve Sénégal, a entrainé le développement de stratégies autonomes individuelles et collectives et des stratégies exogènes par les communautés pour faire face aux effets. En effet, cette situation nécessite des mesures d'accompagnement, des projets et programmes plus spécifiques prenant en compte les stratégies des populations.

INTRODUCTION

En zone intertropicale, l'adaptation aux aléas et la gestion du risque sont partout pris en compte dans les systèmes agraires traditionnels. Les mécanismes en jeu sont basés sur l'auto-assurance (épargne), sur la complémentarité entre spéculations et entre espaces utilisés au sein des exploitations et/ou des communautés. Ils reposent à la fois sur des choix techniques et une organisation sociale, qui se révèlent aujourd'hui de plus en plus souvent insuffisants ou inadaptés.

En effet le changement climatique global se traduit localement par plusieurs évolutions qui modifient les conditions de production. Il s'agit i) de décalages dans les calendriers climatiques (retard dans l'arrivée des pluies notamment) ; ii) de changements dans les hauteurs d'eau reçues annuellement, avec, dans de nombreuses régions, des périodes de sécheresse plus marquées et/ou plus fréquentes ; iii) de la fréquence accrue des phénomènes paroxystiques et des évènements anormaux (cyclones, gelées, températures anormalement élevées); iv) enfin, et partout, d'une très forte variabilité temporelle et spatiale au niveau local.

L'impact de cette évolution du climat est d'autant plus fort que les agricultures familiales subissent aussi d'autres mutations de leur environnement : i) dégradation de la fertilité, ii) déforestation et érosion de la biodiversité, iii) insertion à l'économie de marché et libéralisation, avec ses exigences de compétitivité, iv) position défavorisée pour l'accès aux ressources (eau, foncier notamment), mais également problèmes de financement.

L'impact sur l'agriculture est multiple. Il pèse sur les personnes, sur le capital des exploitations et sur les résultats de ces dernières (systèmes d'élevage et de culture moins productifs), mais également sur les dynamiques collectives, le tout contribuant à accroître la vulnérabilité des plus pauvres. Par exemple, les champs collectifs peuvent être abandonnés ou les dynamiques dans les organisations ou groupements de producteurs et d'éleveurs, de jeunes et de femmes peuvent être réduites fait du changement climatique. Les impacts peuvent également s'étaler également sur les ressources communes (fleuve, marre, forêt, parcours du bétail).

La baisse des rendements (végétaux et animaux), l'impossibilité de faire jouer les mécanismes traditionnels de gestion du risque et la très grande incertitude fragilisent les systèmes et induisent des stratégies de court terme qui sont souvent dommageables à l'environnement voire à la durabilité économique des exploitations.

Dans ces conditions, les paysans tentent de s'adapter. Ils commencent en général par modifier leurs pratiques techniques. Les agriculteurs changent de variétés (recherche de précocité comme facteur d'adaptation à la baisse de pluviométrie), voire d'espèces cultivées pour privilégier des cultures plus rustiques. Les pratiques culturales évoluent également aussi bien sur le plan des dates de réalisation que des techniques employées (abandon du travail du sol dans certains cas par exemple). L'utilisation des moyens de production (travail, intrants) est raisonnée pour tenir compte des risques : cela se traduit dans certains cas par l'extensification, ailleurs par la concentration des moyens sur des espaces « plus sûrs» (du point de vue de l'eau disponible notamment). Chez les éleveurs l'on constate, d'une part, le changement de structure des troupeaux, notamment la répartition entre espèces (caprins, ovins, bovins), et, d'autre part, la modification des calendriers fourragers basés notamment sur la mobilité des troupeaux : changement des zones de pâturage et/ou des dates de déplacement.

La croissance démographique n'est que très partiellement compensée par l'exode rural. A la faveur de certaines situations de tensions ou de conflits, on observe même un mouvement de retour vers les campagnes. L'une des premières conséquences est l'accroissement de la pression foncière qui se traduit elle-même par la mise en culture de terres marginales, par un raccourcissement des périodes de jachère et parfois même par une diminution des surfaces cultivées par actif.

L'impact des changements climatiques sur les agricultures familiales se trouve amplifié ou atténué par l'environnement économique et politique. Au Sénégal, l'État a encore une politique volontariste d'appui à l'agriculture familiale. Malgré, cette politique agricole, la résilience des petits producteurs dans la zone d'étude, ceux qui sont peu intégrés au marché, est plus grande que ceux qui ont un meilleur accès au marché.

Notre zone d'étude n'est pas épargnée par ce phénomène. Malgré l'importance et la diversité des ressources, l'impact négatif de la variabilité climatique prend de plus en plus de l'ampleur. En effet, les populations sont de plus en plus exposées à la vulnérabilité malgré leur grande faculté de résilience. Il est constaté de plus en plus de nouvelles formes d'adaptation pour tenir compte des mutations de l'environnement de production. C'est pourquoi nous nous proposons dans cette étude d'analyser les moyens de productions dont disposent les exploitations agropastorales familiales afin d'évaluer leur niveau de vulnérabilité. Pour ce faire, nous allons nous baser sur certains indicateurs du développement durable (capital humain, naturel, physique, social et financier) pour avoir un meilleur aperçu de la capacité de résilience des exploitations.

I. MÉTHODOLOGIE DE L'ÉTUDE

L'objectif des enquêtes de terrain est de caractériser l'état actuel des ménages dans la zone d'étude en vue d'approfondir la revue bibliographique sur la vulnérabilité des ménages. À travers une évaluation du capital humain, naturel, physique, social et financier des ménages, les enquêtes de terrain permettront d'analyser les facteurs climatiques et non climatiques qui déterminent la vulnérabilité actuelle de ces ménages. Ainsi, la vulnérabilité des ménages engagés dans différents systèmes de production - pastorales, mixtes et cultures sera évaluée.

1.1. Choix des villages

L'étude sur l'évaluation de la vulnérabilité aux changements climatiques avait ciblé 15 villages situés dans les départements administratifs de Matam (Thiancone Hiraye, Hontorbé, Kiriré I, Asndé Balla), Kanel (Ouro Cebo, Ouro Silamako, Boulone Samba Djadji), Bakel (Sinthiou Madina et Samba Kolo) et Goudiry (Mbakanabé, Boynguél Bamba, Gambi, Godioyél Bocar Yoro, Boulel et Koar). Ainsi, l'étude couvre deux zones: la zone nord (départements administratifs de Matam et Kanel) et la zone sud (départements de Bakel et Goudiry). La sélection des villages a été faite selon la position géographique mais en insistant sur la variabilité climatique et l'insécurité alimentaire (cf. CSE, report on selection of survey villages).

1.2. Mission de prospection

Pour évaluer la vulnérabilité des ménages agropastoraux, une mission de prospection a été réalisée pour une meilleure appropriation socioéconomique et agro écologique de la zone d'étude. Cette première prise de contact nous a permis d'informer les chefs de villages ciblés de la tenue des enquêtes et de collecter des informations préliminaires sur les ménages, les activités économiques (agriculture, élevage, commerce, etc.) et les contraintes.

1.3. Dispositif d'enquêtes

Le dispositif d'enquêtes était composé de 12 enquêteurs, 4 facilitateurs, 2 superviseurs et un suppléant. Pour un bon déroulement des enquêtes, ces derniers ont été scindés en deux équipes (Nord et Sud). Chaque équipe était composée d'un superviseur, de 6 enquêteurs et de 2 facilitateurs. Le choix du personnel (superviseur, facilitateur et enquêteurs) a été fait en fonction des critères identifiés dans les termes de référence (cf. Termes de références pour la sélection du personnel, en annexe). Pour une meilleure appropriation des questionnaires et du guide d'entretien, un manuel de l'enquêteur et du superviseur et un guide du facilitateur avait été élaboré et utilisé lors de la formation des enquêteurs. Cette formation avait consisté à:

- expliquer les différents modules des manuels
- échanger avec eux sur ces différents modules
- parcourir les questionnaires en vue d'avoir une même compréhension
- traduire les termes clés dans les langues locales

Le questionnaire a été testé à Thiancone Hiraye par les deux équipes. Pour un bon déroulement des enquêtes, un calendrier des enquêtes a été élaboré pour chaque équipe

(Annexe n°) qui avait en charge d'enquêter 7 villages. Elle devait également séjourner deux jours dans chaque village, à l'exception de Thiancone Hiraye qui était le village pilote.

Le questionnaire a permis de recueillir des informations sur les moyens de production des ménages. Il est structuré autour de sept principaux points: capital humain, capital naturel, capital physique, capital social, capital financier, sécurité alimentaire et eau, assainissement et santé

1.4. Choix des ménages

Dans chaque village, trente (30) ménages ont été enquêtés. Ce qui fait un total de 450 ménages dont 448 valides. Certains villages qui faisaient moins de trente (30) ménages (Ouro Cebbo, Oura Silamaka, Boulone Samba Diadji, Godioyel, Boulel et Sinthiou Madina) ont été associés à d'autres villages pour avoir le nombre requis. Le choix des ménages à enquêter a été réalisé par un tirage successif sans remise.

1.5. Analyse des données

Nous avons utilisé le logiciel SPSS et Excel pour les analyses statistiques en nous focalisant sur les spécificités entre les sous-zones Nord et Sud de la zone d'étude.

II. RÉSULTATS DES ENQUÊTES

2.1. Profil des répondants

Les enquêtes ont été menées auprès des exploitations agricoles familiales de notre zone d'étude (Matam et Tambacounda). Elles ont été administrées, pour la majorité, aux chefs d'exploitation et dans une moindre mesure à des personnes ressources (dépendants) en cas d'absence de ces derniers. Dans les deux sous zones (nord et sud), l'organisation sociale patriarcale fait que les chefs d'exploitation sont en majorité des hommes. Toutefois, on note aussi la présence de certaines femmes, cheffes d'exploitation, particulièrement dans la zone nord, où les femmes représentent un peu moins de 20% (Tableau 1). Ceci peut être expliqué par plusieurs raisons parmi lesquelles le niveau d'éducation ; l'expérience avec les services de vulgarisation (Etats), de projets et programmes et surtout la mobilité des hommes.

Tableau 1 : Répartition des chefs d'exploitation en fonction du genre

Zone	*Chef d'exploitation*		
zone nord	Féminin	**Marié(e)**	**13,7%**
		Veuf (ve)	4,9%
	Masculin	Célibataire	0,5%
		Marié(e)	**81,0%**
zone sud	Féminin	Marié(e)	5,4%
		Veuf (ve)	1,7%
	Masculin	Célibataire	1,3%
		Divorcé(e)	1,3%
		Marié(e)	**89,2%**
		Séparé(e)	0,4%
		Veuf (ve)	0,8%

Source : Enquête ARCC-BAME, 2013

2.2. Capital humain, relations inter et intra familial et activités menées

Les exploitations agricoles familiales sont caractérisées par une utilisation quasi exclusive de la main d'œuvre familiale d'où l'importance, en général, de la population en leur sein. Cette main d'œuvre qui possède une longue expérience des activités menées dans ces exportations est vitale pour leur survie. Dans la zone d'étude, elle est plus ou moins identique entre les deux sous zones, 13 au nord et 14 au sud.

Tableau 2 : Composition du ménage agricole

	ZONE NORD	ZONE SUD
Adulte (Homme et femme)	3,2	3,3
Non apparenté	1,5	1,4
Enfant	8,2	9,0
Personne âgée	0,8	0,5
Exploitation	13,3	14,0

Source : Enquête ARCC-BAME, 2013

Elle est à majorité constituée d'actifs adultes hommes et femmes et surtout d'enfants. Ces derniers ont un rôle incontournable dans la réalisation des principales activités agricoles et pastorales. La particularité est la présence de non apparenté dans les exploitations qui peut s'expliquer par la proximité des frontières avec le Mali et la Mauritanie où des ouvriers agricoles ou des bergers viennent travailler dans ces exploitations. Il faut relever qu'avec la scolarisation des enfants, ils deviennent de moins en moins disponible certaines périodes. Cependant, cette scolarisation arrive rarement à terme comme nous le montre le tableau 3.

Tableau 3 : Niveau d'éducation dans les exploitations agricoles

Niveau d'éducation	ZONE		Zone d'étude
	Nord	Sud	
Aucun	**57,50%**	**41,20%**	**48,80%**
Lire et écrire	2,90%	5,40%	4,30%
Primaire incomplet	1,90%	4,60%	3,40%
Primaire complet	1,00%	0,80%	0,90%
Secondaire incomplet	0,50%	1,20%	0,90%
Post-secondaire	-	0,80%	0,40%
École coranique	**36,20%**	**45,80%**	**41,40%**

Source : Enquête ARCC-BAME, 2013

Il est noté une même tendance globale dans les deux zones. Près de la moitié des membres des ménages (48,8%) ne bénéficie pas d'éducation. Cette frange est souvent représentée par les femmes mais depuis quelques années, on note une certaine émancipation avec la présence de plus en plus des femmes au niveau scolaire. Cependant, aussi bien pour les hommes que les femmes, très peu (0,4%) arrive au terme de leur scolarisation. Toutefois, le contact avec l'éducation permet aux populations d'avoir une meilleure ouverture avec l'extérieur mais aussi de pouvoir mieux communiquer et défendre leurs intérêts. Du fait de leur orientation religieuse, une bonne partie de la population (41,4%), généralement les hommes, disposent d'une éducation coranique.

Cette diversité de personnes au niveau des exploitations induit une multitude d'activités surtout avec l'impact du changement climatique. En effet, les exploitations agricoles familiales sont caractérisées par leur pluriactivité pour augmenter leur résilience face à la précarité de leur environnement. Face à la variabilité climatique mais aussi aux mutations socioéconomiques, les exploitations familiales évoluent de plus en plus vers des systèmes d'activités où les activités non agricoles voient leur importance évoluer. Ainsi, les activités des membres de l'exploitation restent dominées par celles en rapport avec les activités agropastorales et ménagères mais on relève une certaine ouverture vers les activités non agricoles. Elles peuvent être commerciales, professionnelles, scolaires, etc. (Tableau 4).

Tableau 4 : Principales activités des membres des exploitations

Activités	ZONE		Zone d'étude
	Nord	Sud	
Inactif	7,60%	8,60%	8,10%
Etudiant	**21,10%**	**19,20%**	**20,20%**
Travaux agricoles du ménage	**19,50%**	**30,30%**	**24,40%**
Travaux agricoles pour d'autres	1,20%	2,30%	1,70%
Travaux d'élevage du ménage	8,90%	2,00%	5,80%
Travaux domestiques du ménage	**38,10%**	**35,90%**	**37,10%**
Professionnel salarié	0,60%	0,60%	0,60%
Artisanat	1,90%	0,40%	1,20%
Extraction de ressources naturelles (bois/charbon)	0,50%	0,50%	0,50%
Téfanke/Dioula (commerçant animaux)	0,60%		0,30%

Source : Enquête ARCC-BAME, 2013

Pour les activités secondaires, on note une même tendance que les activités principales avec une prédominance des activités agropastorales mais une large part des membres n'en dispose (28%, voir annexe).

Cette diversité des activités montre un dynamisme au sein de l'exploitation pour faire face aux besoins et surtout aux aléas qui viennent de façon récurrente dans la zone. En effet, malgré ces contraintes, ces populations ont un lien très fort avec leur terroir, ce qui fait qu'elles privilégient la recherche de solutions durables. Cet ancrage territorial fait que l'on note un faible niveau de migration mais aussi de transhumance au sein des exploitations (Tableau 5). De plus, on note la même tendance entre les deux sous zones. D'autres études sur la migration faites dans ces deux zones ont montré que les pauvres n'ont pas les moyens de migrer (Isra/Bame, 2012)[11].

[11] Isra/Bame (2012), Rapport de caractérisation de la zone de Rivers : Les systèmes de vie et de production de la haute et la moyenne vallée du Sénégal face aux changements, *Matam, Bakel, Kidira*

Tableau 5 : Migration et transhumance des membres des exploitations durant les douze derniers mois.

Migration et transhumance	Zone		Zone d'étude, 2013
	Nord	Sud	
Migration	4,50%	4,50%	4,50%
Migration et transhumance	0,50%	0,30%	0,40%
Ni migration ni transhumance	93,30%	94,50%	93,80%
Transhumance	1,70%	0,80%	1,30%

Source : Enquête ARCC-BAME, 2013

2.3. Capital naturel

2.3.1. Agriculture

Les principales activités des exploitations sont l'agriculture et l'élevage pour qui le foncier constitue une ressource capitale. Par conséquent, la disponibilité et le contrôle de ce dernier sont des éléments de pouvoir. La société rurale africaine est marquée par une domination masculine qui fait que traditionnellement, la terre est sous l'autorité de l'homme qui a le contrôle économique, les règles de succession religieuses et ou sociohistorique aidant. Cela confère aux hommes les terres les plus importantes et les plus fertiles. Les femmes qui travaillent généralement sous l'autorité des hommes peuvent disposer de terres qui sont souvent marginales et de très petites superficies.

Tableau 6 : Répartition des terres entre hommes et femmes dans les exploitations

zone	Foncier		
	Type de Champs	Moyenne Homme (ha)	Moyenne Femme (ha)
zone nord	Arrosé à la main	3,5	0,8
	Diery	2,2	1,1
	Irriguée	0,9	0,3
	Walo	2,0	1,2
zone sud	Arrosé à la main	-	0,7
	Diery	1,9	1,4
	Irriguée	-	0,03
	Walo	6	-

Source : Enquête ARCC-BAME, 2013

Nous notons la présence de plusieurs types de champs répartis en fonction des écologies. Les superficies sont plus importantes dans la zone sud où la majorité des terres se situent dans le Walo. Au nord, on note une meilleure répartition entre les écologies. Pour les femmes, les superficies sont faibles par rapport aux hommes mais elles disposent des champs les plus importants dans le Diery qui est très soumis aux variations climatiques. Environ 90% des exploitations de la zone dispose entre un à trois champs qui ont en moyenne 1,9 ha dans les deux zones.

Autant les hommes que les femmes, dans leur majorité, sont propriétaires des terres qu'ils utilisent. Dans la zone sud, on note une importance du droit coutumier aussi bien chez les hommes que chez les femmes où près du tiers de l'échantillon dispose des terres selon ce mode. C'est un mode qui permet aux femmes d'accéder à la terre là où les femmes de la zone nord sont obligées d'emprunter des terres pour pouvoir les exploiter. Il serait intéressant de mener une étude autour de cette question pour mieux comprendre ce phénomène de transfert des terres au niveau de la zone sud.

Tableau 7 : Type de régime foncier

Type de régime foncier	Hommes		Femmes	
	zone nord	zone sud	zone nord	zone sud
Donnée en métayage ou loue	1,2%	0,0%	0,6%	0,0%
Droit coutumier	12,2%	31,9%	4,4%	34,3%
Emprunté	7,6%	3,2%	29,4%	8,7%
Prêté	1,5%	0,0%	1,3%	1,7%
Pris en Métayage ou loue	2,3%	0,4%	1,9%	0,4%
Propriétaire	75,3%	64,4%	62,5%	55,0%

Source : Enquête ARCC-BAME, 2013

Globalement, les superficies demeurent identiques pour la majorité des exploitations mais on dénote une diminution pour près du quart des exploitations. On relève aussi une augmentation des superficies pour certaines exploitations mais elle est plus marquée au niveau de la zone sud. Ceci pourrait s'expliquer par la déforestation au niveau de la zone sud qui en est bien dotée en ressources sylvicoles.

Tableau 8 : Évolution des superficies et des besoins en terres dans les dix dernières années

	Superficie			Terre		
	Augmente	Identique	Réduite	Besoin en terres	Terres suffisantes	Terre excédentaire
zone nord	14%	65%	21%	41%	50%	9,60%
zone sud	29%	44%	27%	65%	20%	15,00%

Source : Enquête ARCC-BAME, 2013

Les besoins en terre sont très élevés dans les deux zones. Ils sont plus importants dans la zone sud car il existe des possibilités d'expansion avec la présence des forêts contrairement à la zone nord où cette expansion est limitée par des contraintes naturelles (fleuve) et administratives (frontière pays voisin). Cependant, cette expansion des terres, plus saillante au sud, est limitée par la réglementation qui régit le domaine forestier.

Les principales spéculations cultivées dans les exploitations peuvent différer selon le genre. Les hommes mettent l'accent sur les cultures céréalières vivrières (mil, maïs, sorgho) et l'arachide alors que les femmes, font généralement des cultures maraichères (gombo) et le niébé.

Tableau 9 : Spéculations cultivées par les hommes et les femmes

Cultures	**Homme**					
	cultures principales 1		**cultures principales 2**		**cultures principales 3**	
	zone nord	**zone sud**	**zone nord**	**zone sud**	**zone nord**	**zone sud**
Arachides	3,5%	**16,4%**	6,4%	**7,0%**	**8,6%**	**5,8%**
Aubergines amères	0,0%	0,2%	0,0%	0,2%	0,3%	0,2%
Gombo	0,6%	0,2%	0,3%	0,5%	2,1%	0,9%
Jachère	2,0%	0,2%	1,7%	0,2%	1,8%	0,2%
maïs	**15,4%**	**26,4%**	**11,9%**	**11,9%**	6,4%	3,1%
Melons	1,2%	0,2%	1,7%	0,2%	0,3%	0,5%
Mil	**48,5%**	**34,8%**	**6,7%**	4,0%	4,6%	0,9%
Néant	0,9%	0,4%	**23,5%**	**67,3%**	**48,5%**	**83,0%**
niébé	4,1%	2,2%	**32,3%**	3,2%	10,4%	0,5%
Riz	1,7%	0,2%	1,2%	0,0%	0,0%	0,0%
Sorgho	**15,7%**	**18,4%**	5,2%	3,2%	3,1%	4,0%
Tomates	0,3%	0,0%	0,0%	0,0%	0,3%	0,0%
Fonio	0,0%	0,0%	0,0%	0,2%	0,0%	0,0%
Piment	0,0%	0,0%	0,3%	0,0%	0,0%	0,0%
Autres à préciser	6,1%	0,5%	8,7%	2,0%	**13,5%**	0,9%

Source : Enquête ARCC-BAME, 2013

Tableau 9 (cont.) : Spéculations cultivées par les hommes et les femmes

Cultures	Femme					
	cultures principales 1		cultures principales 2		cultures principales 3	
	zone nord	zone sud	zone nord	zone sud	zone nord	zone sud
Arachides	**20,0%**	**26,9%**	7,5%	1,7%	1,9%	0,8%
Aubergines amères	2,5%	0,8%	3,1%	2,1%	5,0%	1,2%
Gombo	**11,9%**	**36,8%**	6,3%	15,3%	3,8%	2,5%
Jachère	0,0%	0,4%	-	-	0,6%	0,0%
maïs	6,9%	5,4%	2,5%	1,2%	2,5%	0,4%
Melons	0,6%	0,0%	1,3%	1,7%	3,1%	1,2%
Mil	**14,4%**	**3,7%**	3,8%	0,0%	1,3%	0,0%
chou	3,8%	0,4%	0,0%	0,8%	2,5%	2,5%
niébé	**13,8%**	**7,9%**	20,0%	8,7%	6,9%	2,9%
Bissap	1,3%	2,9%	14,4%	7,4%	8,8%	13,6%
Sorgho	5,0%	3,3%	1,9%	0,8%	-	-
Tomates	1,9%	0,8%	0,6%	1,2%	1,9%	0,4%
Riz	1,9%	5,0%	0,0%	2,9%	-	-
oignon	0,0%	0,4%	2,5%	0,4%	2,5%	1,2%
Piment	1,3%	0,0%	0,6%	0,4%	0,0%	0,8%
Néant	2,5%	0,4%	22,5%	52,1%	41,9%	70,2%
Autres à préciser	12,5%	5,0%	13,1%	3,3%	17,5%	2,1%

Source : Enquête ARCC-BAME, 2013

2.3.2. Élevage

L'ancrage culturel de la population dans l'élevage est un atout en raison des savoirs endogènes et de l'expérience capitalisés depuis des siècles et transmis de génération en génération. La zone présente des opportunités avec l'existence de vastes pâturages herbacés et aériens dans le Ferlo, un potentiel important de fourrage dans le Walo (cultures irriguées et décrue), les nombreux points d'eau (cours d'eau ou forage).

Composition du troupeau

L'élevage est très présent dans le quotidien des exploitations agricoles. La composition des animaux au niveau des exploitations agricoles dans les deux zones est similaire. Elle est caractérisée par sa diversité avec une prédominance des bovins et des petits ruminants. Chez les hommes la taille des troupeaux bovins est identique entre les deux zones mais pour les petits ruminants, ils sont légèrement plus importants dans la zone sud. Par rapport aux femmes, les hommes disposent d'un plus grand nombre d'animaux mais aussi d'une plus grande diversité d'espèces. Le troupeau des femmes est dominé par les petits ruminants et la volaille qui sont plus faciles à gérer et à commercialiser. Leurs bovins sont généralement sous la responsabilité des hommes contrairement aux petits ruminants et à la volaille qui est sous leur gestion directe, ce qui leur permet de disposer de sommes d'argent pour faire face aux urgences.

Tableau 10: Composition des troupeaux des hommes et des femmes

	HOMME							
zone	Type de bétail	Taille actuelle	Animaux gérés hors ménage	Animaux extérieur ménage	Perdus 12 derniers mois	Morts 12 derniers mois	Volés 12 derniers mois	Vendus 12 derniers mois
zone nord	Ânes/Mulets	2	0	0	0	0	0	0
	Animaux de trait	2	0	0	0	0	0	0
	Bovin	15	0	1	1	**4**	0	**2**
	Chameaux	0	0	0	0	0	0	0
	Chevaux	1	0	0	0	0	0	0
	Chèvres	**11**	0	0	1	**4**	0	**3**
	Moutons	**23**	2	1	2	**8**	0	**8**
	Volaille	**6**	0	0	0	**5**	0	**1**
zone sud	Ânes/Mulets	1	0	0	0	0	0	0
	Animaux de trait	2	0	0	0	0	0	0
	Bovin	**16**	0	0	1	**4**	0	1
	Chameaux	0	0	0	0	0	0	0
	Chevaux	0	0	0	0	0	0	0
	Chèvres	**6**	0	0	0	**2**	0	1
	Moutons	**13**	1	0	0	**5**	0	1
	Volaille	**5**	0	0	0	**6**	0	1

Source : Enquête ARCC-BAME, 2013

Tableau 10 (cont.) : Composition des troupeaux des hommes et des femmes

	FEMME							
zone	Type de bétail	Taille actuelle	Animaux gérés hors ménage	Animaux extérieur ménage	Perdus 12 derniers mois	Morts 12 derniers mois	Volés 12 derniers mois	Vendus 12 derniers mois
zone nord	Ânes/Mulets	0	0	0	0	0	1	0
	Animaux de trait	0	0	0	0	0	0	0
	Bovin	**4**	0	0	0	**1**	0	1
	Chameaux	0	0	0	0	0	0	0
	Chevaux	0	0	0	0	0	0	0
	Chèvres	**7**	1	0	1	**2**	0	1
	Moutons	**9**	1	0	1	**3**	0	2
	Volaille	**5**	0	0	0	**5**	0	1
zone sud	Ânes/Mulets	0	0	0	0	0	0	0
	Animaux de trait	0	0	0	0	0	0	0
	Bovin	**4**	0	0	0	**1**	0	0
	Chameaux	0	0	0	0	0	0	0
	Chevaux	0	0	0	0	0	0	0
	Chèvres	**4**	0	0	0	**1**	0	0
	Moutons	**2**	0	0	0	**1**	0	0
	Volaille	**5**	0	0	0	**3**	0	0

Source : Enquête ARCC-BAME, 2013

On note aussi la présence des animaux de traits (cheval et âne) qui joue un rôle primordial dans les activités agricoles mais qui sont souvent sous la gestion des hommes. Les chevaux sont moins présents dans la zone sud car ils s'y adaptent difficilement du fait d'une écologie défavorable.

La caractéristique des troupeaux de la zone d'étude est l'importance de la mortalité observée au niveau des différentes espèces mais aussi le faible niveau de vente des bovins par rapport aux petits ruminants. Ceci peut s'expliquer par des aspects sociologiques mais aussi de la demande du marché. En effet, certaines fêtes religieuses permettent de faciliter la commercialisation des à des prix très compétitifs mais aussi la généralisation des « dibiterie » favorise la mise en marché des petits ruminants et particulièrement les caprins.

La gestion du troupeau est extensive avec l'utilisation des pâturages dans les zones de résidence ou dans les régions voisines et les pays frontaliers. Généralement, les troupeaux sont conservés à proximité du lieu d'habitation particulièrement durant la saison des pluies et le début de la saison sèche. Avec le déficit du fourrage durant la saison sèche, certaines exploitations peuvent soit individuellement, soit collectivement emmenées leur troupeau en transhumance ou trouver un berger ou un membre de la famille pour utiliser les parcours de la communauté rurale ou de la région. En effet, durant l'hivernage, entre 80 et 90% des troupeaux sont au niveau de leur lieu de résidence et font des déplacements n'excédant pas 10 km (voir annexe). Durant la saison sèche, les troupeaux se déplacent dans les limites de la communauté rurale ou de la région dans la majorité des cas de la zone d'étude. Toutefois, particulièrement pour certains élevages de la zone nord, on relève un déplacement vers les autres régions ou les pays limitrophes à la recherche du pâturage. Ainsi, les déplacements sont pour la majorité entre 25 et 50 km mais peuvent atteindre 100 km pour les longues transhumances. Ces dernières ne sont pas très fréquentes sont souvent fait par le propriétaire ou les membres de sa famille. L'utilisation des bergers est plus répandue dans la zone sud où plus de la moitié des exploitations en font usage alors que seul ¼ dans le nord en font appel (voir annexe).

Par rapport à la santé animale, les campagnes de vaccination étatique favorise une bonne prophylaxie des animaux. C'est ainsi que l'on observe que dans plus de 80% des cas, les animaux sont vaccinés et le taux est plus important dans la zone sud (83%) par rapport à la zone nord (76%). Cette tendance est observée aussi dans le recours aux services vétérinaires mais avec plus d'acuité. En effet, 60% des exploitations dans la zone sud font recours à ces services contre 36% dans la zone nord (voir annexe).

Aussi bien pour les hommes que pour les femmes, les troupeaux n'évoluent pas en nombre ou ont une tendance à la baisse. Ceci est beaucoup plus accentué dans la zone nord, pour les hommes et pour les petits ruminants.

Tableau 11 : Évolution des troupeaux dans les exploitations agricoles

		Homme			Femme		
	Animaux	**Aucun changement**	**Troupeau augmenté**	**Troupeau diminué**	**Aucun changement**	**Troupeau augmenté**	**Troupeau diminué**
zone nord	Ânes/Mulets	**61%**	9%	31%	93%	3%	4%
	Animaux de traction	**64%**	17%	19%	97%	-	3%
	Bovin	38%	7%	**56%**	**60%**	8%	33%
	Chameaux	98%	-	3%	100%	-	-
	Chevaux	74%	3%	24%	92%	1%	7%
	Chèvres	20%	15%	**66%**	38%	14%	**48%**
	Moutons	14%	9%	**77%**	34%	12%	**54%**
	Volaille	40%	7%	**53%**	38%	3%	**59%**
zone sud	Ânes/Mulets	**86%**	4%	10%	99%	1%	1%
	Animaux de traction	**82%**	7%	12%	100%	-	1%
	Bovin	**46%**	8%	**46%**	**78%**	2%	20%
	Chameaux	99%	-	1%	100%	-	-
	Chevaux	90%	1%	9%	100%	-	-
	Chèvres	**53%**	9%	38%	**67%**	7%	26%
	Moutons	**51%**	6%	43%	**77%**	4%	19%
	Volaille	**55%**	5%	40%	**66%**	4%	30%

Source : Enquête ARCC-BAME, 2013

Les produits d'élevage

Les produits de l'élevage sont assez variés et concernent la viande, le lait et ses sous-produits, les œufs et la peau. Par rapport à la viande, les ruminants sont vendus sur pieds par le biais de différentes stratégies allant du déstockage des animaux conduits en extensifs à la vente d'animaux en embouche. Le lait est produit par 42% des exploitations de la zone d'étude et il est fortement autoconsommé avec une vente réalisée par moins de 5% des exploitations. Il en est de même pour les sous-produits du lait et pour les œufs qui sont aussi majoritairement autoconsommés.

Tableau 12 : Production et vente des produits d'élevage

	Production						Vente					
	zone nord			zone sud			zone nord			zone sud		
	NA	Non	Oui	NA	Non	Oui	NA	Non	Oui	NA	Non	Oui
Lait	1,0%	56,7%	42,3%	-	57,9%	42,1%	1,0%	**94,7%**	4,3%	-	**97,5%**	2,5%
Fromage	1,0%	97,1%	1,9%	-	98,3%	1,7%	1,4%	98,1%	0,5%	-	100,0%	
Lait caillé	1,4%	76,0%	22,6%	-	74,2%	25,8%	1,0%	94,2%	4,8%	-	97,9%	2,1%
Babeurre	1,9%	82,2%	15,9%	-	93,8%	6,2%	2,9%	93,8%	3,4%	-	98,8%	1,2%
Huile de beurre	1,0%	85,1%	13,9%	-	88,3%	11,7%	2,4%	93,3%	4,3%	-	99,2%	0,8%
Œuf	1,4%	79,8%	18,8%	-	81,7%	18,3%	1,4%	96,6%	1,9%	-	97,5%	2,5%
Peau	2,4%	96,6%	1,0%	-	97,9%	2,1%	1,9%	98,1%		-	100,0%	
Fumier	1,9%	76,0%	22,1%	-	85,4%	14,6%	1,4%	97,6%	1,0%	-	99,6%	0,4%

Source : Enquête ARCC-BAME, 2013

La presque totalité du fumier produit dans les exploitations est réutilisée dans les activités agricoles du fait de l'intégration agriculture-élevage. La vente des peaux est faible voire inexistante car les animaux sont vendus à des tiers personnes qui les amènent dans les autres régions du pays.

2.4. CAPITAL PHYSIQUE

Les habitats sont variés et adaptés aux contraintes climatiques et sociologiques de chaque communauté. Vu la diversité des ethnies (toucouleur, peulh, bambara, soninké, …) présent dans la zone d'étude, nous rencontrons un habitat assez varié qui s'insère généralement dans son environnement en y puisant le matériel de construction. Cependant, avec les mutations observées, on s'oriente de plus en plus vers une uniformisation des habitations. En effet, les principaux matériaux de construction sont de plus en plus uniformisés et on relève un passage de l'utilisation des ressources naturelles vers celle de matériels plus solide tels que le ciment et le béton. Toutefois, les habitations de notre zone d'étude reste à majorité confectionnées par du matériel provenant des ressources naturelles particulièrement l'argile et les tiges.

Tableau 13 : Principaux matériaux de construction

Principaux matériaux de construction	Murs		Plancher	
	Zone nord	Zone sud	Zone nord	Zone sud
Argile bois	1,4%	0,8%	6,7%	0,8%
Béton	6,2%	1,7%	**14,9%**	3,8%
Béton ciment	**16,3%**	**14,6%**	**13,9%**	**22,1%**
Ciment	1,4%	2,5%	1,9%	1,7%
Paille	0,5%	-	0,5%	-
Terre argile et ciment	2,4%	1,7%	0,5%	-
Terre/argile	**61,1%**	**76,7%**	**54,8%**	**67,9%**
Tige	10,6%	2,1%	6,2%	2,9%
Tapis plastique	-	-	-	0,4%
Bouses mélangées	-	-	0,5%	6,7%

Source : Enquête ARCC-BAME, 2013

Le matériel pour la confection des toits connait aussi une évolution en partant des chaumes pour maintenant être constitué de tôles ou de toit cimenté. Cette évolution est plus observée au nord de la zone d'étude où l'argent de l'émigration a permis de changer les types d'habitation.

Tableau 14 : Principaux matériaux de construction pour le toit

Principaux matériaux du toit	Zone nord	Zone sud
	1,00%	3,30%
Bois et argile	3,80%	-
Chaume/bois	**32,70%**	**62,90%**
Ciment	**18,30%**	6,20%
Tôles métalliques	**43,30%**	**23,80%**
Terre et agile	0,50%	-
Tiges	-	3,80%
Zinc et argile	0,50%	-

Source : Enquête ARCC-BAME, 2013

Cette construction en dur favorise l'ancrage territorial des populations et une meilleure occupation de l'espace avec des investissements durables. En effet, la mobilité des familles, particulièrement chez les peulhs, est réduite à quelques personnes en cas de transhumance des animaux.

L'agriculture et l'élevage étant les principales activités, les exploitations de la zone d'étude dispose en moyenne d'un grenier et d'un enclos. En effet, les principales cultures céréalières sont généralement autoconsommées d'où la nécessité de disposer d'un local pour leur conservation. De plus, l'élevage a un fort ancrage socioéconomique dans la zone, la présence d'enclos, d'étable ou d'écurie est généralisée dans les exploitations. Cependant, la présence de robinet dans les ménages est très faible particulièrement dans la zone sud où seuls 6% des exploitations en disposent contre 14% dans la zone nord. Il en est de même pour l'électrification qui est plus développée dans la zone nord où on note par endroit l'existence d'un réseau électrique avec l'utilisation des lampes néon. On relève aussi dans la zone nord, l'utilisation de plus en plus du solaire et des téléphones portables pour l'éclairage mais une majorité (38%) continuer d'utiliser les lampes torche (batterie) ou d'autres moyens (bougie, lampe pétrole, feu de bois,…). La zone sud est caractérisée par la généralisation de l'utilisation des lampes torches (76%) mais certaines zones sont électrifiées avec l'utilisation de lampes non (10%).

Tableau 15: Type d'éclairage utilisé dans les exploitations

Type d'éclairage	Zone nord	Zone sud
Batterie de voiture	0,5%	0,0%
Bougie	0,5%	1,7%
Feu de bois	0,5%	0,0%
Lampe pétrole	2,4%	1,7%
Lampe électrique	0,5%	0,0%
Lampe néon	**31,7%**	**9,6%**
Lampe solaire	**8,2%**	7,5%
Lampe torche	**37,5%**	**75,9%**
Réseau électrique	**4,3%**	0,0%
Téléphone portable	**4,8%**	0,0%
Combinaisons	7,0%	2,0%
Autres à préciser	1,4%	0,0%
Aucun	1,0%	1,7%

Source : Enquête ARCC-BAME, 2013

Les exploitations sont très peu dotées en mobilier moderne qui se résume généralement à quelques lits, chaises et tables. Toutefois, l'utilisation de matériels locaux est très importante car plus accessible pour ces populations. L'utilisation de matériel électroménagers est rare car conditionnée par la présence d'un réseau électrique ou d'u module solaire adéquat. Ainsi, l'utilisation de réfrigérateurs, de radios ou de télévisions a une percée timide dans les exploitations avec une plus grande acuité dans la zone nord. Cependant, on note une forte pénétration des téléphones cellulaires dans les exploitations, ce qui augure d'une facilité de communication et d'information.

Tableau 16 : Moyens d'information et de communication

	Radio	Télévision/ DVD	Téléphone cellulaire
Zone nord	1,4	0,1	3,1
Zone sud	1,3	0,1	2,4
Zone d'étude	1,4	0,1	2,7

Source : Enquête ARCC-BAME, 2013

Globalement les exploitations agricoles sont équipées d'un petit matériel agricole leur permettant de mener leurs activités agricoles. Le niveau d'équipement varie en fonction des exploitations avec des incidences sur le niveau de productivité agricole. Dans la zone d'étude, le matériel agricole est très varié et regroupe le matériel attelé et le petit matériel. Cependant, au regard des superficies emblavées, le niveau d'équipement des exploitations reste faible en se basant normes[12] données par l'Institut Sénégalais de Recherches Agricoles (ISRA).

Tableau 17 : Matériel agricole

	Matériel agricole		
	Zone nord	**Zone sud**	**Zone d'étude**
Houe traditionnelle	**1,8**	**3,9**	2,9
Charrue	**0,7**	**0,7**	0,7
Tracteur	0,0	0,0	0,0
Pelles	**0,8**	**0,8**	0,8
Hilaire	0,7	0,3	0,4
Machette/coupe-coupe	**0,9**	**1,0**	1,0
Semoir	0,3	0,4	0,3
Hache	**1,2**	**1,5**	1,4

[12] Taux d'équipement = ((surface concernée par le matériel)/surface totale)*100)

Normes : un semoir super Eco pour 4 ha, une houe occidentale pour 3 ha, une souleveuse pour 5 ha, une charrette équine pour 10,5 ha, une charrette asine pour 7,5 ha

Faucille	**1,3**	**1,1**	1,2
houe occidental	0,2	0,1	0,2
houe sine	0,3	**1,4**	0,8

Source : Enquête ARCC-BAME, 2013

Le matériel agricole est plus important dans les exploitations de la zone sud surtout pour les matériels de préparation du sol mais on dénote un déficit au niveau des semoirs. Ce déficit du matériel a souvent une répercussion négative sur le calendrier cultural avec des incidences sur la productivité des exploitations.

Le matériel de transport est constitué principalement de charrettes et de vélos. Il est plus important dans la zone sud où on peut trouver aussi des motos du fait de la proximité avec le Mali et le Guinée.

Tableau 18 : Moyens de transport des exploitations

Moyens de transport	**zone nord**	**zone sud**	**Zone d'étude**
Mobylette/Moto	0,0	0,3	0,2
Vélo	0,1	0,9	**0,5**
Charette	0,7	0,6	**0,6**
Camion/Camionnette	0,0	0,0	0,0
Voiture	0,0	0,0	0,0

Source : Enquête ARCC-BAME, 2013

2.5. Capital social

Dans la zone d'étude, on rencontre plusieurs organisations sociales auxquelles adhèrent les éleveurs et producteurs agricoles. Ces organisations sont le lieu d'entraide et de solidarité (travaux collectifs), mais également d'épargne (tontine). Dans les villages de l'étude, les activités sportives et de soutien à l'école sont aussi observées.

2.5.1. Association de producteurs

De façon globale, dans la zone de l'étude, environ 21% des paysans appartiennent des organisations de producteurs et 16% à des associations d'éleveurs. Dans les zones nord et sud, environ 20% seulement des producteurs sont membres d'une association. Le tableau 19 ci-après résume l'appartenance des producteurs rencontrés à des organisations. D'un point de vue global, seulement le ¼ des producteurs agricoles enquêtés a adhéré à des organisations. Ce qui dénote de la faible coopération entre producteurs agricoles de la zone de l'étude, comparée

à la situation un peu plus vers le centre (bassin arachidier) où environ plus de 50% des producteurs sont membres d'organisation de producteurs.

Tableau 19: Appartenance à des organisations de producteurs

zone	Association de producteurs		Total
	Non	Oui	
Nord	80,3%	19,7%	100,0%
Sud	78,3%	21,7%	100,0%
Total	79,2%	20,8%	100,0%

Source : Enquête ARCC-BAME, 2013

Le nombre de réunions par an reste faible ; 59% des producteurs font une et deux réunions par an. Dans les zones nord et sud de l'étude, la plupart (59,5% pour le nord et 58,5% pour le sud) des paysans font également entre une et deux réunions par an. Ce qui est faible au vue des nombreuses contraintes du secteur agricole et des défis à relever dans le cadre de la sécurité alimentaire et du changement climatique. Seule une faible partie des producteurs (13%) ont quatre réunions et plus par an.

2.5.2. Association d'éleveurs

Dans l'échantillon global, le nombre de chef d'exploitation appartenant à des associations d'éleveurs (16%) reste faible également comme dans le cas des producteurs agricoles. Plus de 80% des chefs d'exploitation interviewés n'adhèrent pas à des organisations d'éleveurs, aussi bien au nord comme au sud. Le tableau 20 ci-après donne les statistiques sur l'adhésion des chefs d'exploitation à des organisations d'éleveurs.

Tableau 20 : Appartenance à des organisations d'éleveurs

		Association d'éleveurs		Total
		Non	Oui	
zone	zone nord	83,7%	16,3%	100,0%
	zone sud	83,8%	16,2%	100,0%
Total		83,7%	16,3%	100,0%

Source : Enquête ARCC-BAME, 2013

Le nombre de participation à des réunions varie selon les chefs d'exploitation. Dans l'échantillon global, 60% des chefs d'exploitation participant à des associations d'éleveurs ne font pas plus de deux réunions par an. Dans la zone sud, 57% des chefs d'exploitation assistent une à deux réunions par an contre 64% pour la zone nord. Seulement 8% de l'échantillon assistent à 4 réunions par an.

De façon générale, on note une faible adhésion des chefs d'exploitation à des associations de producteurs (20%) ou d'éleveurs (16%).

2.5.3. Travaux collectifs

La participation à des travaux collectifs est également faible (11% seulement). Dans le nord, le taux de participation est de 8% contre 14% dans le sud. Près de 50% des chefs d'exploitation enquêtés ne participent pas à plus de deux travaux collectifs et 7% seulement participent à quatre travaux collectifs dans l'année. Ce qui laisse entrevoir l'effritement des formes de solidarités et d'entraide autrefois en légion en milieu paysan. Ce qui peut s'expliquer par une baisse d'activité en milieu rural et un manque de main d'œuvre, relatif à un exode massif des hommes vers les villes ou l'étranger.

Tableau 21 : Travail collectif

		Travaux collectifs	
		Non	**Oui**
zone	**zone nord**	91,8%	8,2%
	zone sud	85,8%	14,2%
Total		88,6%	11,4%

Source : Enquête ARCC-BAME, 2013

2.5.4. Banque de semences

Les réserves de semences sont très rares et sont faites par très peu de chefs d'exploitation enquêtés ; seulement 4% des exploitations. Dans la zone nord, 2% des exploitations seulement réservent des semences contre 5% pour la zone sud. Les raisons évoquées sont liées à une insuffisance de la production, la qualité de la semence et le manque de magasin de stockage.

Tableau 22 : Echanges de semences

		Banque de semences		**Total**
		Non	**Oui**	
zone	**zone nord**	97,6%	2,4%	100,0%
	zone sud	94,6%	5,4%	100,0%
Total		96,0%	4,0%	100,0%

Source : Enquête ARCC-BAME, 2013

2.5.5. Organisation et tranches d'âge

Dans les villages de façon générale, les associations regroupement des personnes de différentes tranches d'âge. Il arrive que ces organisations regroupent des personnes de même génération. Le plus souvent les associations religieuses (regroupement confrérique) fédèrent des personnes

de même âge ou de même génération. Dans la zone de l'étude, environ 36% de l'échantillon disent avoir fait partie dans des organisations associatives où les membres sont de même génération. Dans la zone nord, 26% des répondants participent à des associations ou organisations regroupant des personnes de même génération contre 45% pour le sud.

Les rencontres sont très peu nombreuses. Elles dépassent rarement deux réunions par an pour environ 60% de l'échantillon. Dans la zone nord, près de 51% des répondants ne participent pas plus de deux fois aux réunions dans ces organisations, contre 62% pour le sud.

La dynamique des organisations semble plus importante dans la zone sud que dans celle du nord.

2.5.6. Clubs sportifs (ASC, Nawétanes)

Dans l'échantillon global, environ 30% participent à des activités sportives au sein des villages de l'enquête. Les activités sportives sont saisonnières (*Nawétanes*) et se passent pendant l'hivernage. En fonction des zones, la participation à ces activités sportives varie. Elle concerne près de 38% pour la zone sud et 19% pour le nord. Le nombre de participation par chef d'exploitation est également variable. Il ne dépasse rarement quatre participations par année pour 73% des exploitations enquêtées. Dans les deux zones nord et sud, respectivement 70% et 74% des exploitations dépassent pas quatre participations à des activités sportives. Ce qui peut s'expliquer par la concurrence de ses activités avec celles agricoles et non agricoles.

2.5.7. Groupe d'épargne solidaire/Tontine

Les formes d'épargne et de crédit sont multiples dans les villages de l'enquête. La plupart du temps, ces formes d'épargne et de crédit sont informelles et utilisent les réseaux sociaux pour financer une activité, financer un besoin ou faire face à une situation ponctuelle (cérémonie familiale, religieuse, …).

En considérant l'ensemble des exploitations enquêtées, la pratique de l'épargne ou des tontines reste faible ; elle est présente que chez 25% des chefs d'exploitation. Une analyse de la pratique de la tontine ou de l'épargne au niveau des deux zones produit le même résultat (environ 25%). La fréquence des réunions est faible. Environ 62% des enquêtés n'organise des tontines ou n'épargne qu'une seule fois par mois. En revanche, 19% des exploitations épargne ou organise des tontines que deux fois par mois et 3% des chefs d'exploitation participent à des tontines que trois fois le mois.

2.5.8. Comité scolaire

Les comités scolaires sont des groupements de parents d'élèves qui sont unis dans le but de parler, d'agir et soutenir l'éducation scolaire des enfants dans les villages. La participation est libre et volontaire. Très peu de chefs d'exploitation (17%) participent à des comités en rapport au système scolaire.

Dans la zone nord, 4% seulement des chefs d'exploitation participent à un comité scolaire contre 28% dans la zone sud. On note là, une inégalité dans la prise en compte de la question de l'enseignement scolaire des enfants dans les deux zones nord et sud, même si de façon générale, l'implication des chefs d'exploitation dans les activités scolaires est faible. De plus, même chez les chefs d'exploitation qui adhèrent à des comités scolaires, la participation aux

réunions est faible. Dans l'ensemble de l'échantillon, près de 83% des chefs d'exploitation ont participé que quatre fois par année, aux réunions de comité scolaire auquel ils ont adhéré. Dans les deux zones, près de 80% (90% pour la zone nord et 82,5% pour la zone sud) n'assistent pas à plus de quatre réunions de comité scolaire par an.

La participation à d'autres types d'activité en dehors de celles développées ne concerne de 12% des exploitations agricoles interviewées.

2.5.9. Solidarité sociale et formes d'aide reçue et leur provenance

Dans les villages de l'échantillon, les échanges sous forme de don et de contre-don sont des pratiques qui se font depuis de très longues années. L'aide peut provenir de membres d'un même village et des habitants de divers villages, d'une ONG ou un projet et du gouvernement. Ils s'observent également entre amis, voisins et parents. La caractéristique principale est l'existence à la fois de flux monétaire et physique (produits, biens).

Tableau 23 : Provenance des aides

zone	**Amis/Voisin**		**Parents**		**ONG/Projet**		**Gouvernement**		**Agence des Nations Unies**
	Non	Oui	Non	Oui	Non	Oui	Non	Oui	Non
Zone Nord	87,50%	12,50%	85,10%	14,90%	93,3%	6,7%	94,2%	5,8%	100,0%
Zone Sud	76,20%	23,80%	82,50%	17,50%	96,3%	3,8%	95,8%	4,2%	100,0%

Source : Enquête ARCC-BAME, 2013

Dans l'échantillon total, 18% des personnes enquêtées ont reçu des aides provenant de leurs amis ou voisins. Dans le nord, 12% des chefs d'exploitation ont reçu des aides dans les 12 derniers mois contre 23% dans la zone sud.

Les aides ont des fréquences variables ; elles sont octroyés annuellement, mensuellement ou à la semaine. Dans l'échantillon global, 13,8% des chefs d'exploitation reçoivent de l'aide annuellement, contre 3% et 2% qui le reçoivent respectivement mensuellement et hebdomadairement. Dans la zone nord comme dans la zone sud, très peu de chefs d'exploitation reçoivent des aides par semaine (2%).

Les aides provenant de parents ne concernent que 16% des chefs d'exploitation. Dans le nord, les aides ont touché 15% contre 17% des chefs d'exploitation dans le sud. Elles ont des fréquences variables selon les zones et départements. La majeure partie des chefs d'exploitation bénéficiaires reçoivent l'aide annuellement (11%).

Les aides provenant des ONG et projets et du gouvernement sont limitées et très modestes. Dans la zone nord, 6% des exploitations seulement ont reçu de l'aide des ONG et du gouvernement contre respectivement 3% et 4% pour les ONG et le Gouvernement. Parmi les exploitations enquêtées, aucune n'a reçu de l'aide provenant des Nations Unis.

- Les types d'aide reçu le plus souvent sont de l'argent, la nourriture, de l'appui en matériel de traction animale, des semences et des vêtements entre autres.

- Pour les ONG et projets, les principaux types d'aide sont la construction de latrine, la distribution de semences améliorées et d'outils agricoles.
- L'aide du Gouvernement est essentiellement constituée de vivres et d'aliment bétail subventionné ou non pendant les périodes de soudure.

2.5.10. Justification des aides reçues

Les différentes formes d'aide se justifient principalement par la crise économique et des conséquences sur les populations, les effets du changement climatique sur les rendements (faibles) et les mauvaises récoltes, absence du mari mais surtout le manque de vivre. Dans les villages de l'enquête, les productions agricoles ne couvrent pas les besoins alimentaires annuels de l'exploitation (à voir plus loin)

2.5.11. Les formes de don rencontrées

Dans les villages de l'échantillon, les exploitations reçoivent des dons mais en distribuent également entre amis, voisins et parents.

Les types de don sont essentiellement le partage de la nourriture, donner de l'argent, des vêtements, prêter ou donner des outils agricoles, de la semence, des animaux de trait entre autres. Le partage de nourriture reste le type de don le plus fréquent. Le tableau 24 ci-dessus expose les principaux types de don.

Tableau 24 : Principaux types de don

Zone	Partage de nourriture		Argent		Outils		Semences		Animaux de Traction		Autres	
	Non	Oui	Non	Oui	Non	Oui	Non	Oui	Non	Oui	Non	Oui
zone nord	76,00 %	24,00 %	78,80 %	21,20 %	97,10 %	2,90 %	96,20 %	3,80%	94,70 %	5,30 %	91,80 %	8,20 %
zone sud	53,80 %	46,20 %	83,30 %	16,70 %	96,20 %	3,80 %	79,60 %	20,40 %	92,90 %	7,10 %	97,10 %	2,90 %
Total	64,10 %	35,90 %	81,20 %	18,80 %	96,70 %	3,30 %	87,30 %	12,70 %	93,80 %	6,20 %	94,60 %	5,40 %

Source : Enquête ARCC-BAME, 2013

Dans la zone nord, les dons en nourriture concernent 24% des exploitations contre 46% dans la zone sud. Les dons en argent ont atteint 21% et 16% des exploitations, respectivement dans le nord et le sud. Ce qui n'est pas négligeable et témoigne d'un certain état de vulnérabilité à la pauvreté. Les autres types de dons (outils, semences, animaux et autres) sont modestes sur l'ensemble de l'échantillon (voir tableau 24).

2.6. Capital financier

Activités génératrices de revenu

Les activités génératrices de revenu sont diverses au niveau des exploitations agricoles et pastorales (cf tableau 25).

Tableau 25 : Principales activités génératrices de revenu

	Travaux d'élevage pour d'autres	Travail non qualifié pour d'autres (agriculture)	Travail qualifié (maçon, menuisier,	Professionnel salarié	Extraction de ressources naturelles (bois/charbon	Artisanat	Petit commerce	Marabout	Pêche/vente de poissons	Provenant de l'exode ou de l'émigration
zone nord	6%	7%	15%	6%	6%	10%	15%	6%	3%	25%
zone sud	6%	10%	11%	8%	9%	7%	15%	8%	2%	24%

Source : Enquête ARCC-BAME, 2013

Les revenus provenant de l'exode ou de l'émigration sont les plus importants, 25% au nord et 24% au sud. La deuxième source de revenus est le petit commerce qui participe à hauteur de 15% dans les revenus du ménage, au nord comme au sud de la zone de l'étude. Le travail d'artisans constitue à la troisième source de revenus pour les ménages et participent respectivement pour 15% et 11% au nord et au sud aux revenus des exploitations. De manière générale, les activités exercées par les exploitations agricoles sont variées mais on peut relever la pêche est très peu pratiquée.

Epargne et crédit

L'épargne et le crédit ne sont très développés dans la zone de l'étude. Les niveaux d'épargne sont particulièrement faibles et varient de 75 F à près de 30 000 FCFA. Chaque exploitation possède en moyenne un membre qui participe à un groupe d'épargne (crédit rotatif). Au sein de chaque exploitation, il existe au moins un membre qui a adhéré auprès d'une institution de finance. Au vu de l'éloignement des villages, il convient de dire qu'il s'agit plutôt des mutuelles d'épargne et de crédit. L'expérience des exploitations dans la microfinance est variable. Elle oscille entre 1 et 6 ans. Les exploitations dans le sud utilisent plus les institutions de microfinance que celles du nord de la zone de l'étude. Ceci peut s'expliquer par l'importance de la migration dans la zone sud. Dans cette zone, la plupart des exploitations ont un membre à l'étranger et la France reste la destination privilégiée.

2.7. Sécurité alimentaire

Dans le tableau 26, les pourcentages représentent la proportion des ménages qui consomment la production suivant les mois de l'année (2ème ligne du tableau). Par exemple, dans la zone nord, pour 9% des exploitations, la production agricole ne couvre qu'un seul mois de consommation.

La sécurité alimentaire des exploitations agricoles varie en fonction des zones et dans une même zone, en fonction des exploitations. Dans la zone nord, 30% des exploitations agricoles consomment leurs productions agricoles pendant 6 mois et plus contre 68% dans le sud. Les résultats des enquêtes que nous avons menées montrent clairement que le nord reste plus vulnérable que le sud. Néanmoins, il subsiste de nombreuses poches de vulnérabilité dans le sud.

Tableau 26 : Nombre de mois de consommation couvert par la production agricole

	Sécurité alimentaire pendant l'année (mois)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**aucun=0**
zone nord	9%	9%	16%	15%	13%	7%	6%	7%	4%	1%	1%	4%	10%
zone sud	0%	2%	8%	8%	8%	10%	9%	10%	8%	3%	3%	25%	6%

Source : Enquête ARCC-BAME, 2013

Les périodes de soudure coïncident avec les mois de Juillet et Aout où les exploitations manquent sérieusement de stock alimentaire et d'argent pour faire face au besoin alimentaire des membres de l'exploitation. Cette période correspond également à celle où les productions horticoles et halieutiques sont faibles, ce qui ajoute beaucoup à la vulnérabilité des exploitations.

2.8. Importance de la sécheresse et des inondations

L'expérience des exploitations avec la sécheresse est variable selon les zones nord et sud et selon les exploitations dans une même zone. Dans la zone nord, seul 9% des exploitations n'ont pas connu de sécheresse dans l'année contre 28% dans la zone sud. En revanche, 72% des exploitations dans la zone nord ont connu entre une et quatre (1 et 4) sécheresses dans l'année contre 65% dans la zone sud. Le tableau ci-après donne un aperçu sur l'importance des sécheresses dans la zone de l'étude.

Tableau 27 : Importance des sécheresses dans la zone de l'étude

zone	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**
zone nord	9,1%	16,3%	25,0%	19,7%	11,1%	7,2%	5,8%	1,4%	1,0%	3,4%
zone sud	27,9%	12,9%	17,5%	23,3%	12,1%	3,8%	2,5%			
Total	19,2%	14,5%	21,0%	21,7%	11,6%	5,4%	4,0%	0,7%	0,4%	1,6%

Source : Enquête ARCC-BAME, 2013

Les inondations sont très peu fréquentes dans la zone du projet. Dans la zone sud, 91% de l'exploitation n'ont pas connu d'inondations dans les 12 derniers mois contre 69% dans la zone nord. Dans la zone nord, seul 26% des exploitations déclarent avoir connu entre 1 et 3 inondations contre 7% au sud. Dans l'ensemble, le nombre d'inondations est faible.

2.9. Stock de semences

La constitution de stocks de semence concerne 50% des exploitations de l'échantillon. Même si le type de semence n'a pas été spécifié, on peut dire qu'il s'agit plus de stock de semences de céréales (maïs, mil, sorgho) que d'autres semences comme l'arachide. Les exploitations du sud sont plus concernées (64%) par la constitution de stock de semence que celles de la zone nord (35%).

2.10. Régime alimentaire et diversification

Les aliments les plus consommés dans la semaine sont les céréales, le sucre et le miel et enfin le café et le thé. Les céréales restent l'aliment de base au nord comme au sud de la zone de l'étude, elles sont consommées près de 17 fois dans la semaine. Dans la zone nord, le sucre et le miel sont consommés 16 fois dans la semaine et 10 fois pour la zone sud. Dans l'échantillon global, la moyenne de consommation du sucre et du miel dans la semaine est de 12 fois. Le café et le thé sont consommés en moyenne 15 fois pour les exploitations de la zone nord et 10 fois pour celle du sud, dans la semaine.

En revanche, les consommations hebdomadaires moyennes de fruits jaunes, d'œufs et de boissons et gâteaux sont très faibles. En moyenne, la viande est consommée entre une (nord) à deux fois (sud) par semaine. La consommation hebdomadaire de poisson est un peu plus importante, elle est de 8 fois pour le nord et 5 fois pour le sud.

De façon générale, les régimes alimentaires des exploitations sont variés. Mais, dans certaines exploitations agricoles, les quantités consommées de produits sont faibles, mais le régime est varié. Le tableau 28 ci-après donne une description des principaux produits consommés dans la semaine par les exploitations au moment des enquêtes.

Tableau 28 : Principaux produits consommés dans la semaine par les exploitations

Régime alimentaire et diversification															
	Moyenne														
Zone	Céréales	Tubercules	Légumes feuille	Légumes fruit	fruits jaunes	Autres fruits	Toute viande	œufs	Poissons frais ou	légumineuse et les	Lait ou produits	Huile, graisses	sucre, miel	café et thé	Boissons et gâteaux
zone nord	17,93	5,29	7,91	8,09	,60	3,18	1,79	,41	8,49	8,17	6,16	9,50	16,14	14,95	,52
zone sud	16,57	3,02	4,87	5,04	,37	1,85	2,25	,45	4,97	6,72	4,05	5,07	10,09	10,20	,23
Total	17,20	4,07	6,28	6,46	,48	2,47	2,04	,43	6,60	7,40	5,03	7,13	12,90	12,41	,36

Source : Enquête ARCC-BAME, 2013

2.11. Hygiène, eau, et assainissement

Dans la zone de l'étude, 70% des exploitations enquêtées affirment certains de leurs membres sont chroniquement malades. Ce qui n'est pas négligeable lorsque l'on considère l'échantillon.

Les exploitations du sud sont plus affectées par les maladies (76% et 75% respectivement pour Bakel et Goudiry). Les maladies chroniques sont également très importantes dans la zone de Kanel (72% des exploitations enquêtées). Matam est la zone la moins touchée avec 57% des exploitations concernées par des cas de malades chroniques.

Le nombre d'exploitations touchées par les cas de malades chroniques nous semblent particulièrement élevé. Il faut juste signaler que les enquêtes se sont déroulées juste après l'hivernage et pendant les récoltes. Cette période est marquée par des pics de paludisme. Le tableau ci-dessous illustre le pourcentage de malades chroniques enregistré dans chaque zone lors de nos enquêtes.

En moyenne, 51% des exploitations de l'échantillon affirment avoir enregistré un malade durant les quatre dernières semaines et qui s'est absenté à son travail.

Tableau 29: Pourcentage de malades chroniques enregistré dans chaque zone

Sites	**Non**	**Oui**
Bakel	23,3%	76,7%
Goudiry	25,0%	75,0%
Kanel	27,8%	72,2%
Matam	42,4%	57,6%
Total	**29,9%**	**70,1%**

Source : Enquête ARCC-BAME, 2013

Les exploitations enquêtées utilisent pour la plupart l'eau du robinet du village (33%) et les puits, seul 1% des exploitations ont un robinet dans leur exploitation. Dans la zone sud de l'étude, 34% des exploitations utilisent des forages et 51% le robinet du village. En revanche, dans la zone nord, 4% des exploitations enquêtées utilisent des forages et 74% utilisent le robinet du village. Le tableau 30 donne les différentes sources d'eau des exploitations.

Tableau 30 : Différentes sources d'eau des exploitations.

Sites	Autres à préciser	Eaux des puits et du robinet du	Forage dans le village	Forage/puits amélioré en dehors du village	Pompe/robinet de village	Puit ménage/village	Puits creusé à la main en dehors du	Robinet village	Robinet ménage	Robinet voisin
Bakel			30,0%	33,3%	28,3%	8,3%				
Goudiry	0,6%			0,6%	22,8%	71,7%	3,3%	0,6%	0,6%	
Kanel					3,3%	95,6%	1,1%			
Matam		1,7%		4,2%	73,7%	15,3%			3,4%	0,8%
Total	0,2%	0,4%	4,0%	5,8%	33,0%	53,1%	1,6%	0,2%	1,1%	0,2%

Source : Enquête ARCC-BAME, 2013

La distance entre la source d'eau et l'exploitation est peu variable selon les zones. Le temps de marche représente en moyenne dix minutes à un quart d'heure de marche.

CONCLUSION

Les exploitations agricoles familiales utilisent quasi exclusivement la main d'œuvre familiale. Elle est constituée en majorité d'actifs adultes hommes et femmes et surtout d'enfants, qui ont un rôle incontournable dans les activités agricoles et pastorales. Les principales activités des exploitations sont l'agriculture et l'élevage. La composition des animaux au niveau des exploitations agricoles est similaire dans les deux zones. Elle est caractérisée par une prédominance des bovins et des petits ruminants. La coopération entre producteurs agricoles de la zone de l'étude est faible et leurs mayens limités. Dans l'échantillon global, le nombre de chef d'exploitation appartenant à des associations d'éleveurs et de producteurs reste faible.

Les activités génératrices de revenu sont diverses au niveau des exploitations agricoles et pastorales et proviennent essentiellement de l'exode ou de l'émigration.

La sécurité alimentaire des exploitations agricoles varie en fonction des zones et dans une même zone, en fonction des exploitations. Les périodes de soudure coïncident avec les mois de Juillet et Aout.

La constitution de stocks de semence concerne la moitié des exploitations de l'échantillon et concernent plus les céréales (maïs, mil, sorgho) que d'autres semences comme l'arachide. Les exploitations du sud sont plus concernées par la constitution de stock de semence que celles de la zone nord.

Les aliments les plus consommés dans la semaine sont les céréales, le sucre et le miel et enfin le café et le thé. Les céréales restent l'aliment de base au nord comme au sud de la zone de l'étude. Les régimes alimentaires des exploitations sont variés. Les exploitations enquêtées utilisent pour la plupart l'eau de robinet du village et les puits. Les superficies sont plus importantes dans la zone sud. Pour les femmes, les superficies cultivées sont faibles par rapport aux hommes. Elles disposent de champs dans le Diery qui est fortement soumis aux variations climatiques. Les exploitations enquêtées utilisent pour la plupart l'eau du robinet et les puits. Une très faible proportion détient un robinet dans leur exploitation. Le changement climatique est une réalité si non se base sur les constatations faites au niveau du climat et des changements intervenus dans les différentes écologies de la zone. Ces perturbations ont entrainé des changements de comportement, faisant naitre des stratégies autonomes individuelles et collectives et des stratégies exogènes aux communautés pour faire face aux effets du changement climatique. La sécurité alimentaire des populations s'en trouve affectée et l'insécurité alimentaire est variable d'une zone à une autre. Cette situation appelle à des mesures d'accompagnement, des projets et programmes plus spécifiques prenant en compte les stratégies actuelles des populations d'atténuation du changement climatique. Par ailleurs, la zone nord a reçu plus d'interventions de l'Etat, des programmes et projets que la zone sud du Sénégal.

Dès lors, on peut se demander quelles stratégies mettre en place et où ? Pour qui et pourquoi ?

ANNEXES

Occupation secondaire 12 derniers mois	Zone Nord	Zone Sud	Zone d'étude
sans réponse	26,2%	28,0%	27,2%
Artisanat	1,7%	0,5%	1,0%
Aucune activité	23,8%	30,9%	27,7%
Élève/Étudiant	0,9%	1,0%	0,9%
Extraction de ressources naturelles (bois/charbon)	0,3%	0,8%	0,6%
Marabout	0,0%	0,3%	0,2%
Pêche/vente de poissons	0,1%		0,0%
Petit commerce	1,1%	1,1%	1,1%
Professionnel salarié	0,1%	0,1%	0,1%
Tefanke/Dioula	0,4%	0,2%	0,3%
Travail non qualifié pour d'autres (manœuvre)	0,2%	0,5%	0,3%
Travail qualifié (maçon, menuisier, mécanicien)	0,3%	0,7%	0,5%
Travaux agricoles du ménage	30,0%	20,7%	24,9%
Travaux agricoles pour d'autres	0,4%	1,7%	1,1%
Travaux d'élevage du ménage	7,2%	8,0%	7,7%
Travaux d'élevage pour d'autres	0,3%	0,5%	0,4%
Travaux domestiques du ménage	6,9%	5,1%	5,9%

Activité Secondaire	STUDY ZONE		Zone
	North	South	
Inactifs	35,70%	43,10%	39,00%
Etudiant	1,20%	1,50%	1,30%
Travaux agricoles du ménage	39,70%	30,30%	35,50%
Travaux agricoles pour d'autres	0,60%	2,70%	1,50%
Travaux d'élevage du ménage	10,70%	11,50%	11,00%

Travaux domestiques du ménage	8,90%	8,40%	8,70%
Professionnel salarié	0,20%	0,20%	0,20%
Petit commerce	0,10%		0,00%
Artisanat	2,00%	0,80%	1,40%
Extraction de ressources naturelles (bois/charbon)	0,40%	1,50%	0,80%
Tefanke/Dioula	0,60%	0,20%	0,40%

Nombre de Champs	zone nord	zone sud	Zone d'étude
0	5,80%	2,10%	3,50%
1	56,30%	40,50%	**46,70%**
2	22,00%	29,90%	**26,80%**
3	9,30%	18,00%	**14,60%**
4	4,10%	6,70%	**5,70%**
5	1,60%	2,10%	1,90%
6	0,50%	0,50%	0,50%
7	-	0,20%	0,10%
13	0,30%	-	0,10%

	Berger payé	
	Non	Oui
zone nord	74,00%	26,00%
zone sud	48,30%	51,70%

	Lieu de garde du troupeau

		Autre région du Sénégal	Dans communauté rurale	Dans région	Dans village	Mali/Mauritanie/Gambie
Saison pluvieuse	zone nord	0,5%	5,3%	0,5%	93,8%	-
	zone sud	2,5%	16,7%	0,4%	80,4%	-
Saison sèche	zone nord	9,6%	9,6%	6,7%	72,1%	1,9%
	zone sud	2,1%	9,2%	0,8%	87,5%	0,4%

		Distance village par rapport lieu de garde du troupeau				
		0-10km	10-25km	100km +	25-50km	50-100km
Saison pluvieuse	zone nord	95,2%	2,9%	1,4%		0,5%
	zone sud	93,8%	3,8%	1,7%	0,4%	0,4%
Saison sèche	zone nord	9,6%	9,6%	6,7%	72,1%	1,9%
	zone sud	2,1%	9,2%	0,8%	87,5%	0,4%

		Non	Oui
Vaccination animaux	zone nord	23,6%	76,4%
	zone sud	17,1%	82,9%
Autres recours services vétérinaires	zone nord	63,9%	36,1%
	zone sud	40,8%	59,2%

zone	Greniers ou magasins pour les céréales	Parc/Enclos/écurie
Zone nord	1,0	1,1
Zone sud	1,4	1,0
Zone d'étude	1,2	1,1

	Robinet dans le ménage	
	Non	Oui
Zone nord	86%	14%
Zone sud	94%	6%

zone	zone nord	zone sud	Zone d'étude
Réfrigérateur	0,01	0,00	0,00
Table	0,2	0,5	0,4
Chaises	0,7	0,9	0,8

ANNEX W. NATIONAL STAKEHOLDER EVENT AGENDA

EVALUATION DE VULNERABILITE AU CHANGEMENT CLIMATIQUE DANS L'EST DU SENEGAL – USAID/SENEGAL

PRESENTATION DES RESULTATS

Hôtel des Almadies, Dakar, 15 septembre 2014

Objectifs de l'atelier:

- Faire prendre conscience des enjeux et implications potentielles du changement climatique sur les moyens d'existence dans l'Est du Sénégal.
- Améliorer la compréhension des contraintes et opportunités en relation avec l'adaptation au changement climatique au Sénégal.
- Echanger sur les stratégies d'adaptation potentielles et formuler des recommandations prioritaires.

Documents de référence:

- Version provisoire du rapport sur l'Evaluation de vulnérabilité au Sénégal (août 2014) (version anglaise)
- Résumé du rapport de l'Evaluation de vulnérabilité au Sénégal (version française)
- Feuille de notation des recommandations

Intervenants:

- *David Miller*, Conseiller technique ARCC[13] pour l'Afrique
- *Mahamadou Baro,* Consultant-chercheur à ARCC et animateur de l'atelier
- *Sylwia Trzaska*, Climatologue à ARCC, Consortium pour un réseau international d'information en sciences de la terre, Institut de la Terre à l'Université de Columbia
- *Jen Graham,* Soutien logistique ARCC et animateur de l'atelier

[13] ARCC: *African and Latin American Resilience to Climate Change Program* (Programme de résilience au changement climatique en Afrique et en Amérique latine)

Programme de l'atelier :

Horaire	Activités
8:30	**Enregistrement des participants**
9:00	**Bienvenue et ouverture** • Ouverture officielle par le Ministre de l'Agriculture et de l'Equipement rural et mots de bienvenue par l'USAID
9:15	**Présentation des objectifs et de l'ordre du jour pour les sessions du matin** ***Objectifs:*** • Présentation des résultats de l'évaluation à un groupe élargi de décideurs et Partenaires techniques et financiers au Sénégal • Faire prendre conscience des enjeux et des implications potentielles du changement climatique sur les moyens d'existence dans les zones rurales de l'Est du Sénégal
9:30	**Présentation de l'évaluation**
10:30	Pause-café
10:45	**Présentation de l'évaluation**
11:30	**Questions et observations/commentaires**
12:15	Déjeuner
1:30	**Présentation des objectifs et de l'ordre du jour pour les sessions de l'après-midi** ***Objectifs:*** • Priorisation des recommandations proposées pour faire face aux impacts du changement climatique dans l'Est du Sénégal • Discussions techniques sur les mérites des différentes approches préconisées pour faire face au changement climatique
1:45	**Organisation et démarrage d'une analyse multicritères** • Validation de la liste des recommandations et des critères • Explication du processus, organisation des groupes de travail • Les groupes de discussion démarrent l'évaluation
2:30	Pause-café
3:30	**Présentation en plénière des notes et observations proposées par les groups**
4:00	**Présentation et discussion des classements combinés et recommandations**
5:00	Fin

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEX X

SEPTEMBER 2014

This report is made possible by the support of the American people through the U.S. Agency for International Development (USAID). The contents are the sole responsibility of Tetra Tech ARD and do not necessarily reflect the views of USAID or the U.S. Government.

ARCC

African and Latin American
Resilience to Climate Change Project

ANNEX X. POWERPOINTS PRESENTED AT THE NATIONAL STAKEHOLDER MEETING

USAID FROM THE AMERICAN PEOPLE

ARCC | African & Latin American Resilience to Climate Change

A USAID funded project implemented by TetraTech/ARD

EVALUATION DE LA VULNÉRABILITÉ AU CHANGEMENT CLIMATIQUE DANS L'EST DU SENEGAL

Atelier de restitution et hiérarchisation des recommandations

Dakar, 15 septembre 2014

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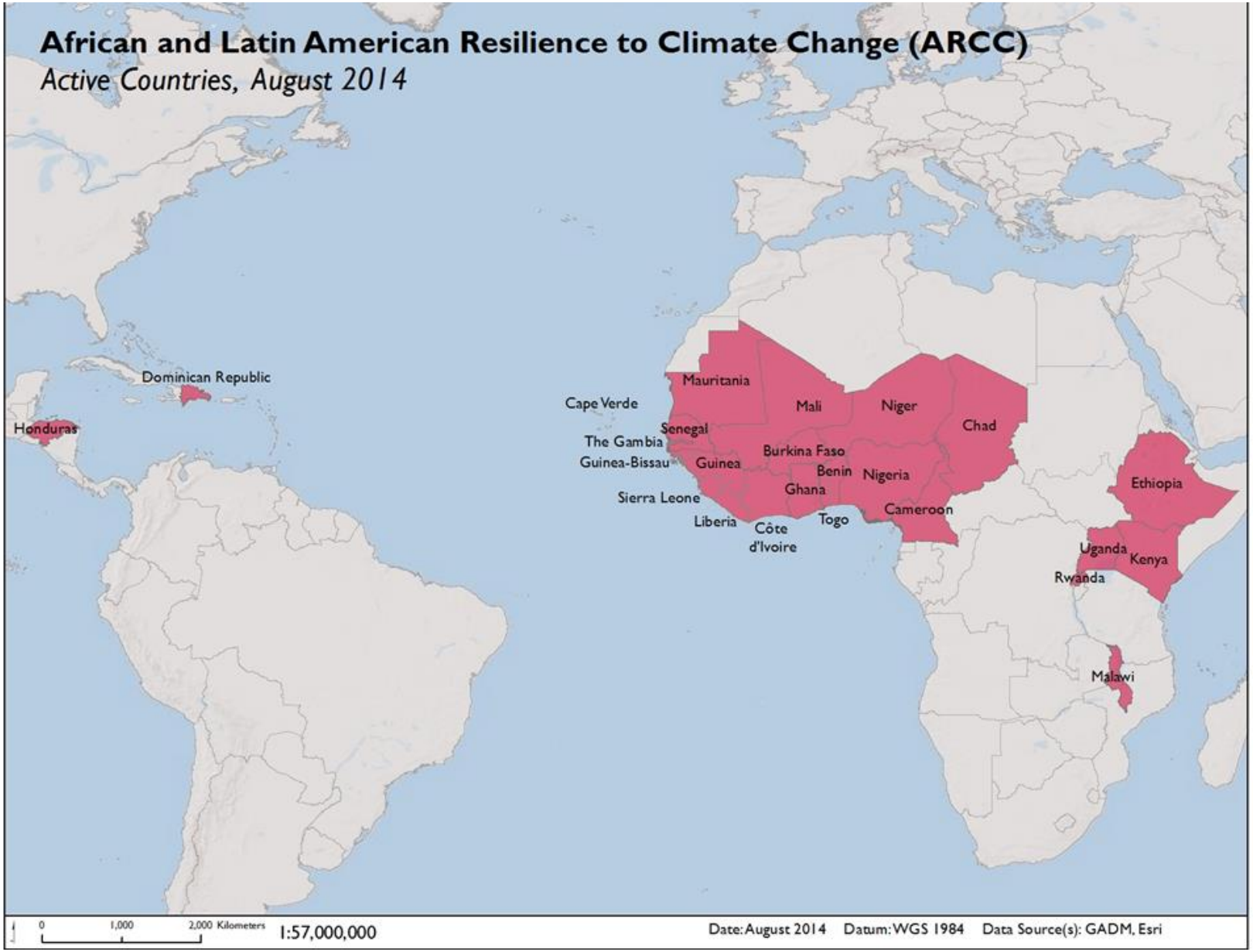
PLAN DE LA PRÉSENTATION

- Introduction à l'ARCC et à l'étude
- Cadre de recherche
- Méthodologies

Introduction à l'ARCC et à l'étude


African and Latin American Resilience to Climate Change (ARCC)
Active Countries, August 2014
Dominican Republic
Honduras
Mauritania
Cape Verde
Mali
Niger
Chad
Senegal
The Gambia
Guinea-Bissau
Guinea
Burkina Faso
Benin
Nigeria
Ghana
Sierra Leone
Liberia
Côte d'Ivoire
Togo
Cameroon
Ethiopia
Uganda
Kenya
Rwanda
Malawi
0
1,000
2,000 Kilometers
1:57,000,000
Date: August 2014
Datum: WGS 1984
Data Source(s): GADM, Esri

LES ÉTUDES DE L'ARCC, MENÉES EN AFRIQUE DE L'OUEST

THÈMES ABORDÉS PAR LES ÉTUDES ARCC EN AFRIQUE DE L'OUEST

- Que conclut la recherche scientifique sur la façon dont le climat va changer en Afrique de l'Ouest?
- Quel impacts auront les changements climatiques sur:
  - les ressources en eau
  - les conflits
  - Et l'agriculture pluviale en Afrique de l'Ouest?

- Etudes portant sur ces questions au Mali

SUR VOUS DES CLÉS USB

LES 2 ETUDES DE FOND

- **VULNÉRABILITÉ AUX CHANGEMENTS CLIMATIQUES : une présentation de l'évaluation pour l'Afrique Occidentale**
- **PROJECTIONS RELATIVES AUX CHANGEMENTS CLIMATIQUES : Statut Et Avenir Des Projections Climatiques En Afrique Occidentale**

RESSOURCES EN EAU ET LE CHANGEMENT CLIMATIQUE

- **CHANGEMENTS CLIMATIQUES DANS LA COTE OCCIDENTALE DE AFRIQUE : Vulnérabilité Aux Impacts des Changements Climatiques et Besoins Institutionnels**
- **GESTION DES EAUX SOUTERRAINES : Réponse Aux Menaces Représentées par les Changements Climatiques**
- **GESTION DES COURS D'EAU TRANSFRONTALIERS**

LES ETUDES SUR LES CONFLITS ET LE CHANGEMENT CLIMATIQUE

- Comment le CC, et d'autres facteurs, affecteront ils les conflits dans les zones agro-pastorales du Sahel? (Études de cas: le Niger et le Burkina Faso)
- Comment le CC, et d'autres facteurs, affecteront les conflits dans les grandes villes côtières en Afrique de l'Ouest? (Études de cas: Lagos et Accra)

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L'ADAPTATION AGRICOLE AU CHANGEMENT CLIMATIQUE DANS LE SAHEL

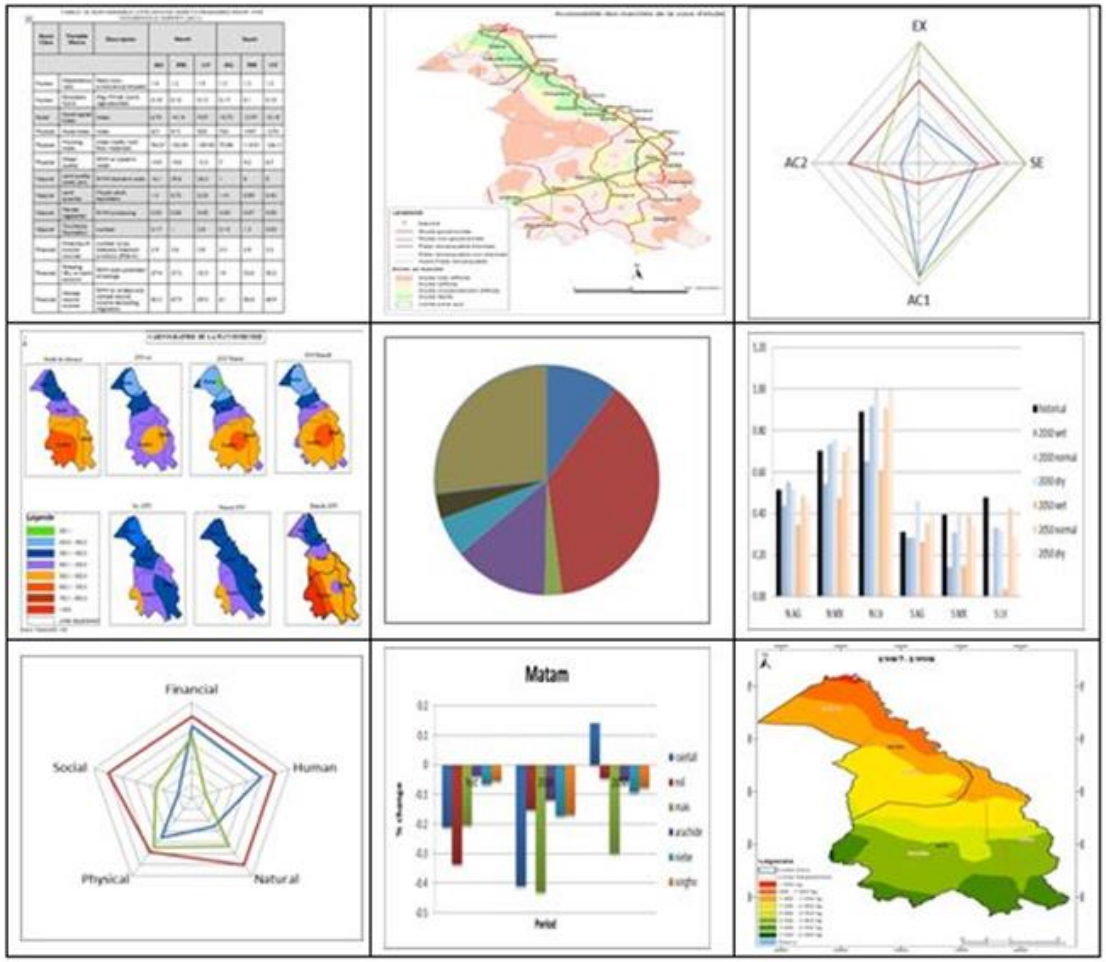
- **DEPISTAGE DES CULTURES AU SAHEL SELON LEUR VULNÉRABILITÉ AUX CHANGEMENTS CLIMATIQUES : Une Approche Phénologique**
- **ÉVALUATION DES PRATIQUES AGRICOLES AU SAHEL : Évaluation des Performances des Mesures d'Adaptation**
- **PROFILS AGRONOMIQUES DE QUINZE CULTURES IMPORTANTES POUR LE SAHEL**
- **PROFILS DES PRATIQUES AGRICOLES AU SAHEL : Une Analyse des Pratiques des Exploitations Agricoles Locales, des Technologies Et des Méthodes**
- **PARASITES ET MALADIES DU BÉTAIL AU SAHEL: Impact Potentiel Des Changements Climatiques**
- **ENNEMIS DES CULTURES AGRICOLES AU SAHEL : Impact Potentiel Des Changements Climatiques**

ETUDES PORTANT SUR CC AU MALI

- CARTOGRAPHIE DE LA VULNÉRABILITÉ AUX CHANGEMENT CLIMATIQUES DU MALI : Collecte et Dissémination d'Informations a Propos d'un Futur Incertain
- PRATIQUES AGRICOLES PROMOUES ET ADOPTÉES AU MALI : Résultats d'une Enquête Auprès des Organisations Non Gouvernementales et de Groupes de Réflexion Chez Les Agriculteurs
- RESSOURCES EN EAU DU MALI : Questions clés dans le contexte des changements climatiques
- RÉCUPÉRATION DE L'EAU DANS L'AGRICULTURE MALIENNE : Évaluation De Son Efficacité Selon Différents Scénarios De Changement Climatique
- MODELISATION DE L'INCIDENCE DE CERTAINES PRATIQUES AGRICOLES ADAPTATIVES

http://community.eldis.org/ARCC

EVALUATION DE LA VULNÉRABILITÉ AU CHANGEMENT CLIMATIQUE DANS L'EST DU SENEGAL



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LES ÉTAPES DE L'ÉVALUATION

I. Mission d'exploration

II. Collecte et l'analyse des données

III. Validation & hiérarchisation des options

COLLABORATEURS DE L'ÉTUDE AU SÉNÉGAL

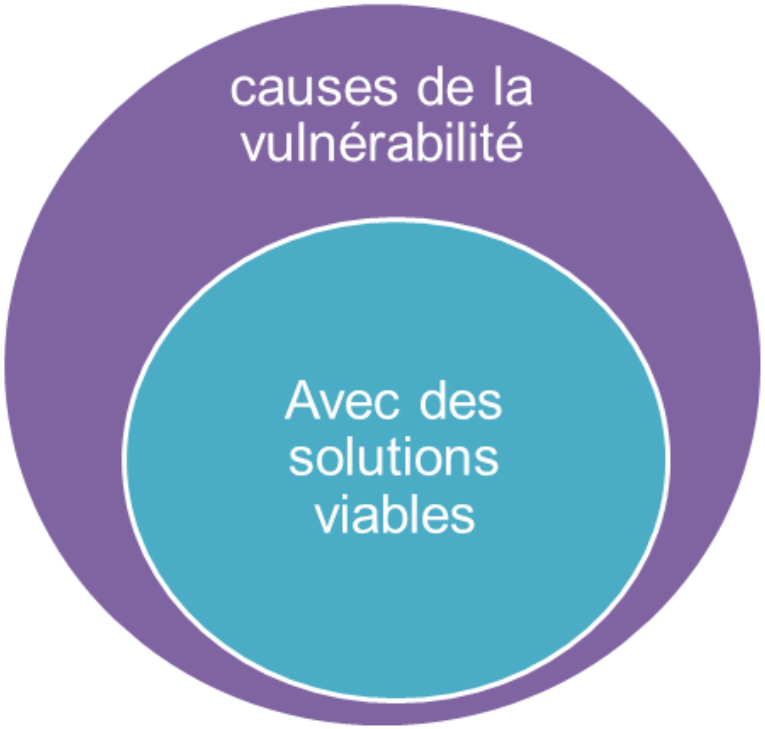
Institut Sénégalais de Recherches Agricoles (ISRA)

Le Centre de Suivi Ecologique (CSE)

Center for International Earth Science Information Network

World Resources Institute

OBJECTIF GLOBAL DE L'ÉTUDE

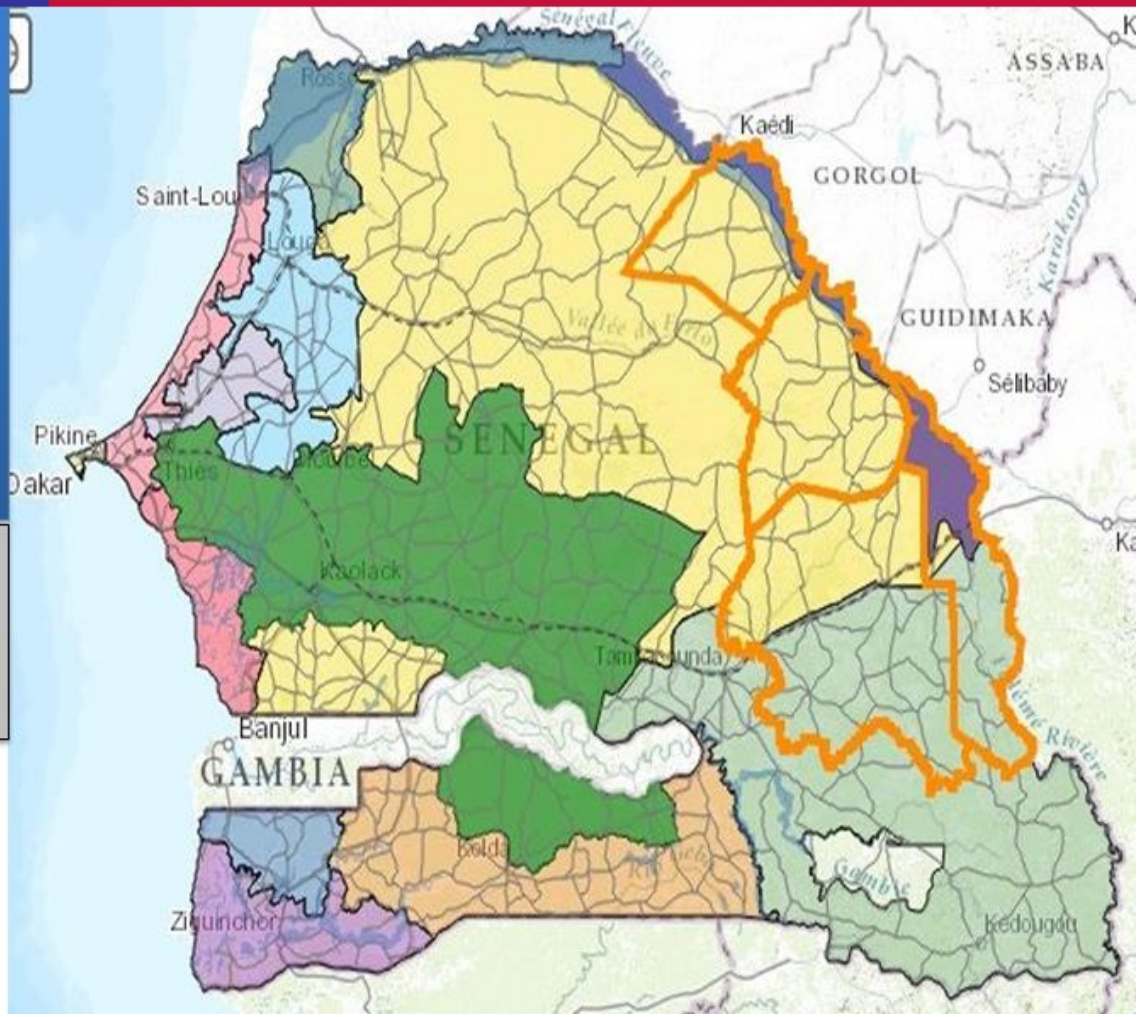


DÉFINITION DE LA ZONE D'ÉTUDE

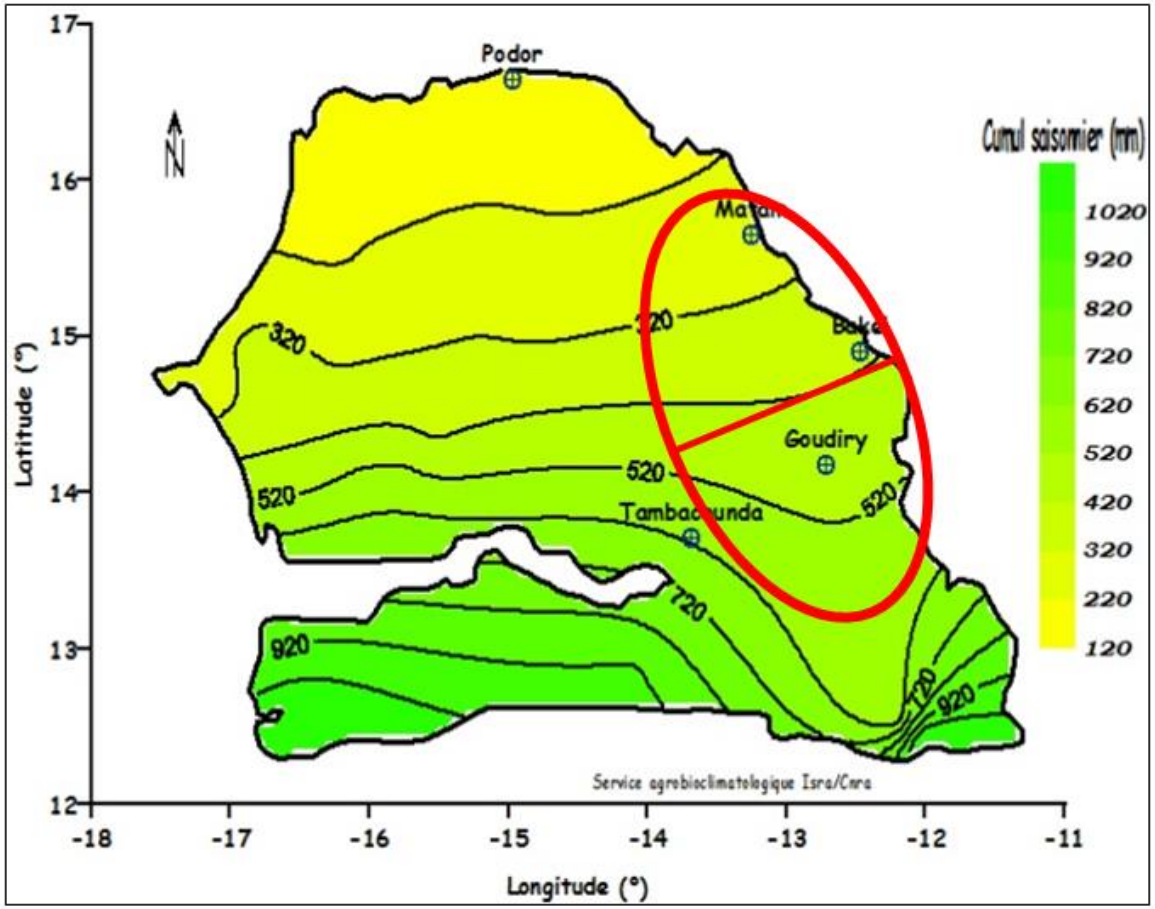
Zones agro-pastorales pluviales de l'Est du Sénégal

- Taux élevés de malnutrition
- L'insécurité alimentaire
- L'investissement sur le changement climatique limité

- **MATAM**
- **KANEL**
- **BAKEL**
- **GOUDIRY**



PRÉCIPITATIONS ANNUELLES



HYPOTHÈSE

« les ménages dont les moyens de existence dépendant de l'élevage de bétail sont moins vulnérables au changement climatique que les ménages dépendant principalement des cultures agricoles pour leur subsistance »

QUESTIONS CONCERNANT LA *VULNÉRABILITÉ*

- Dans la zone de l'étude, lequel des trois systèmes de production étudiés (à dominante agricole, mixte, à dominante pastorale) engendre une **vulnérabilité plus importante** des ménages face à la variabilité climatique ?

- Comment la vulnérabilité relative des ménages liée à chacune de ces différentes stratégies de existence **évoluera-t-elle** à court et à long terme ?

- Quels **facteurs clés** rendent vulnérables les ménages dépendant de ces différentes stratégies de existence?

QUESTIONS CONCERNANT LES *SOLUTIONS D'ADAPTATION*

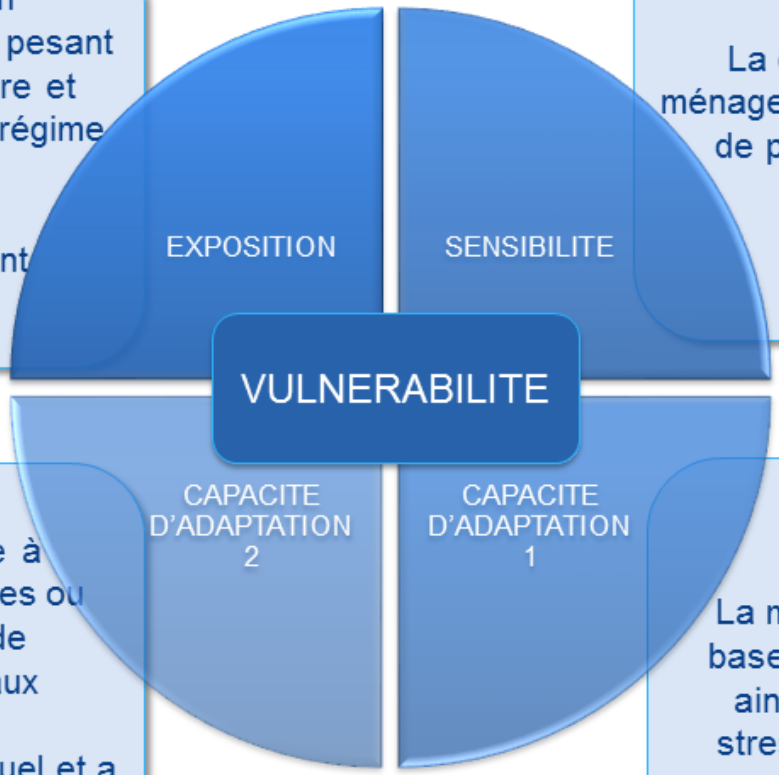
- Quelles sont les stratégies d'adaptation disponibles pour les ménages de la zone de l'étude, et dans quelle mesure seront-elles capables de réduire la vulnérabilité au changement climatique à court et à long terme ?

- Quelles sont, sur le plan **institutionnel**, les solutions permettant de renforcer l'adaptation efficace à l'échelle locale ?

- Quelles sont les solutions **en matière de recherche et de vulgarisation** permettant de renforcer l'adaptation à l'échelle locale ?

ELEMENTS DE L'ETUDE

Les limites biophysiques imposées par le climat, en particulier les contraintes pesant sur les systèmes de culture et d'élevage produits par le régime des précipitations et des températures.
Ces paramètres échappent largement au contrôle de l'homme.



La dépendance relative des ménages à l'égard de systèmes de production affectés par le climat.

La capacité d'un ménage à modifier ses circonstances ou son comportement afin de s'adapter efficacement aux tendances et aux chocs climatiques externes actuel et a venir.

La mesure de cet élément se base sur les actifs du ménage ainsi que sur les facteurs de stress pesant sur les moyens de subsistance.

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THÈMES ET MÉTHODOLOGIES: *VULNÉRABILITÉ*

1. Climat (actuel et projeté)
2. Cultures & l'élevage (modélisation)
3. Institutionnelle (40 entretiens avec des informateurs clés)
4. Moyens de existence (15 villages)
5. Accès au marché (analyse spatiale, examen documentaire)

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MÉTHODOLOGIES: *SOLUTIONS D'ADAPTATION*

1. Stratégies d'adaptation locales (30 discussions dirigées de groupe)

2. Stratégies d'adaptation locales historique (examen documentaire)

3. Stratégies nationales et régionales d'adaptation dans la zone d'étude (examens documentaires et consultation avec des experts)

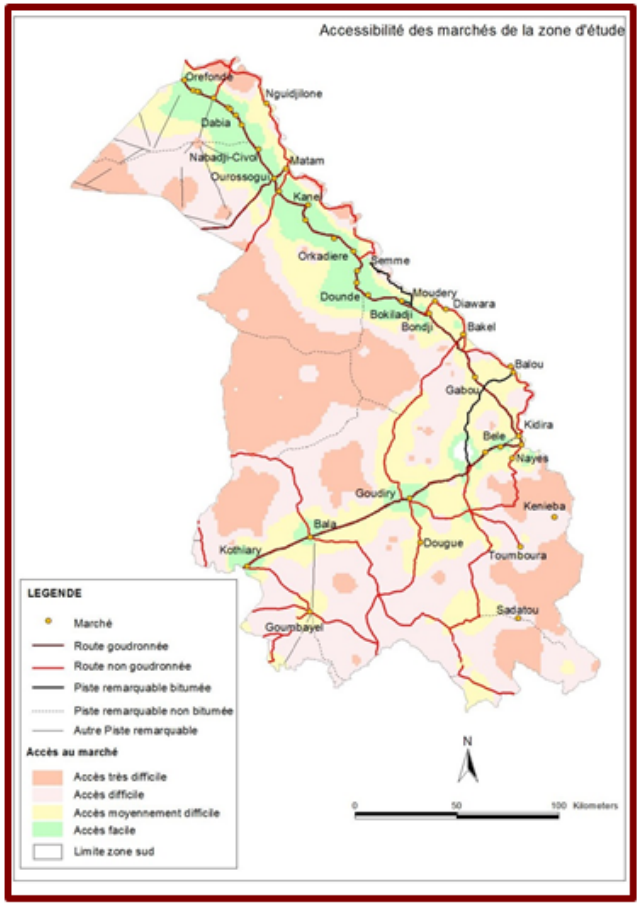
D'AUTRES ÉTUDES DANS LE RAPPORT

ANALYSE DE L'ACCES AUX MARCHES ET DES IMPACTS POTENTIELS DU CHANGEMENT CLIMATIQUE POUR LES PERIODES 2030 ET 2050 (CSE)

REVUE BIBLIOGRAPHIQUE : VULNERABILITE ET MARCHES (ISRA:BAME)

CHANGEMENTS CLIMATIQUES ET RÉPONSES LOCALES DANS LA RÉGION EST DU SÉNÉGAL ET AU SAHEL: APPRENDRE DES SÉCHERESSES PASSÉES POUR MIEUX S'ADAPTER (DR. HENRI LO)

SYNTHÈSE DES TRAVAUX DE RECHERCHES ET DE VULGARISATION DANS LE DOMAINE DE L'AGRICULTURE ET DES CC (ISRA)



ÉVALUATION DE LA VULNÉRABILITÉ DU SÉNÉGAL FACE AU CHANGEMENT CLIMATIQUE

MÉTHODES MIXTES

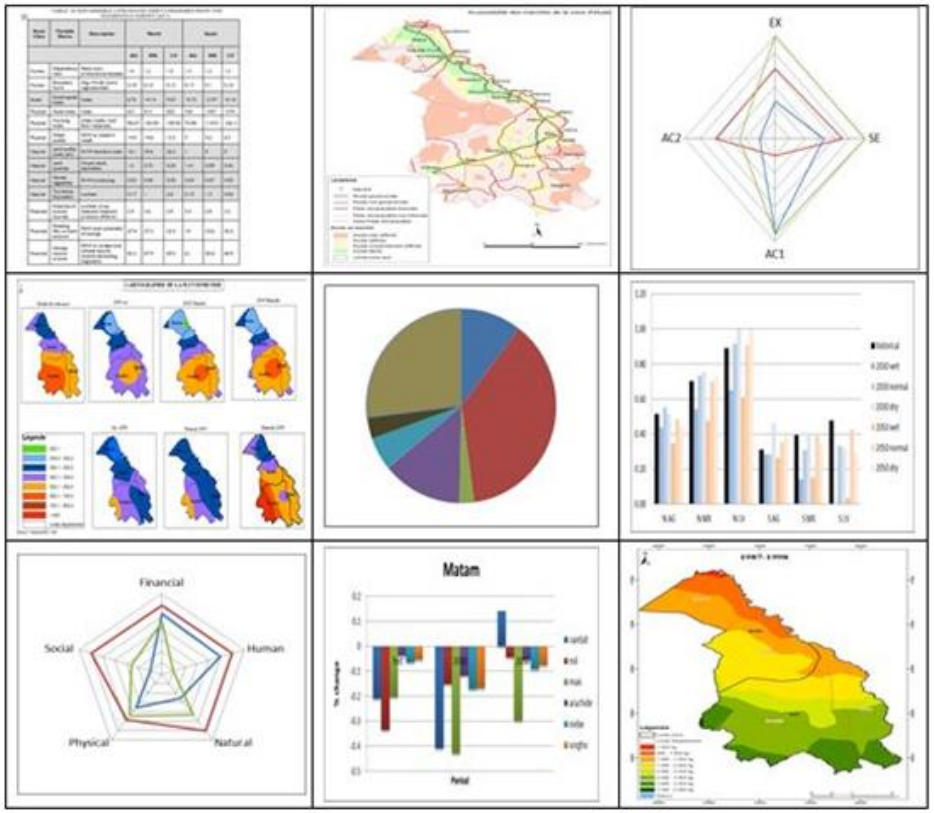
NOVATEUR

COLLABORATION

LE RENFORCEMENT DES CAPACITÉS

L'INTÉGRATION ET L'ANALYSE CROISÉE

QUALITATIVE ET QUANTITATIVE



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SYSTÈMES D'EXISTENCE ET VULNÉRABILITÉ DES MÉNAGES FACE AUX CHANGEMENTS CLIMATIQUES

SYSTÈMES D'EXISTENCE ET VULNÉRABILITÉ DES MÉNAGES

SOMMAIRE

- Aperçu Méthodologique
- Contexte & Aperçu des Moyens d'Existence
- Portefeuilles dominants: agriculture, élevage
- Capacités d'adaptation
- Tendances et quelques axes de conclusion

SYSTÈMES D'EXISTENCE ET VULNÉRABILITÉ DES MÉNAGES

- **Aperçu Méthodologique**
- Contexte & Aperçu des Moyens d'Existence
- Portefeuilles dominants: agriculture, élevage
- Capacités d'adaptation
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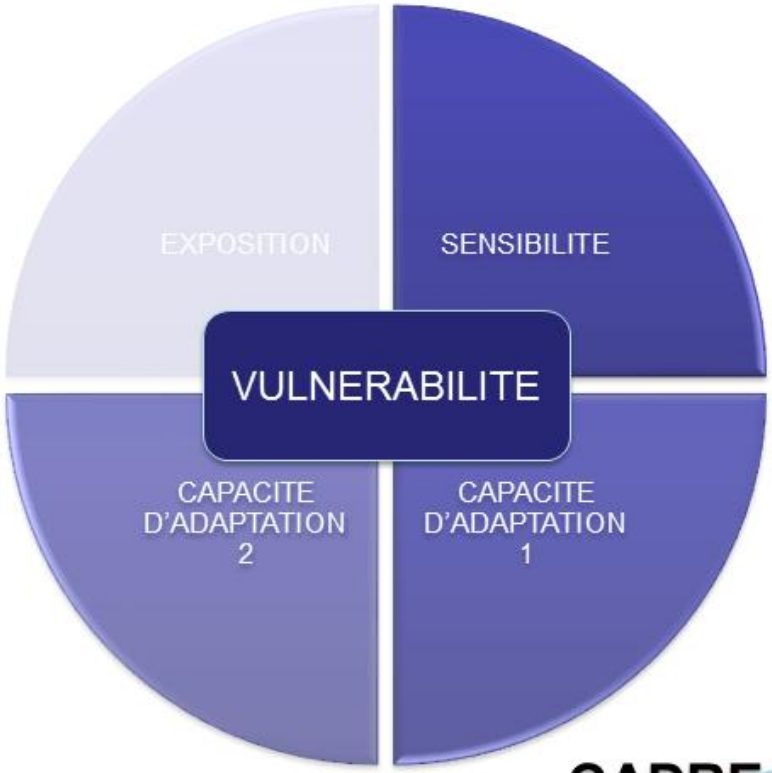
COMPOSANTES DE LA VULNERBILITE



CADRE CONCEPTUEL

APERÇU MÉTHODOLOGIQUE

QUESTION PRIORITAIRE DE RECHERCHE

Lequel de ces trois systèmes de subsistance dominants (Agriculture, Elevage et Mixte) est le plus vulnerable, Qu'est ce qui motive leur vulnérabilité et comment cette vulnérabilité va évoluer au cours du temps.

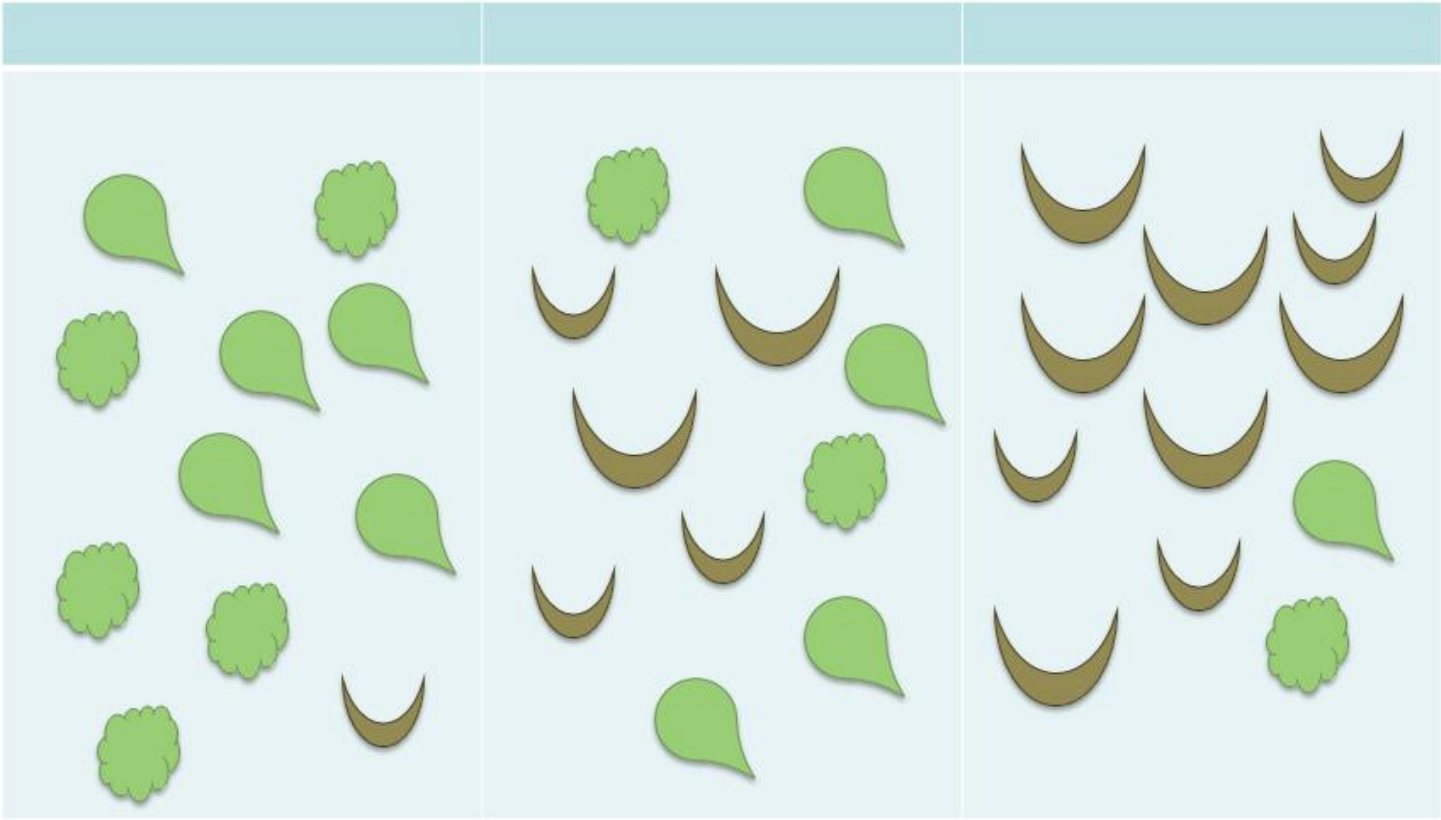
APERÇU MÉTHODOLOGIQUE

Approche méthodologique mixte triangulant:

- Enquêtes de 450 ménages
- 40 Entretiens diriges
- Entretiens Communautaires dans 15 communautés
- 30 « Focus groups »
- & des Observations de terrain.

➔Aperçu des Moyens d'Existence

APERÇU MÉTHODOLOGIQUE



AG | MX | EL

ELEMENTS DE DEFINITIONS DES MOYENS D'EXISTANCE

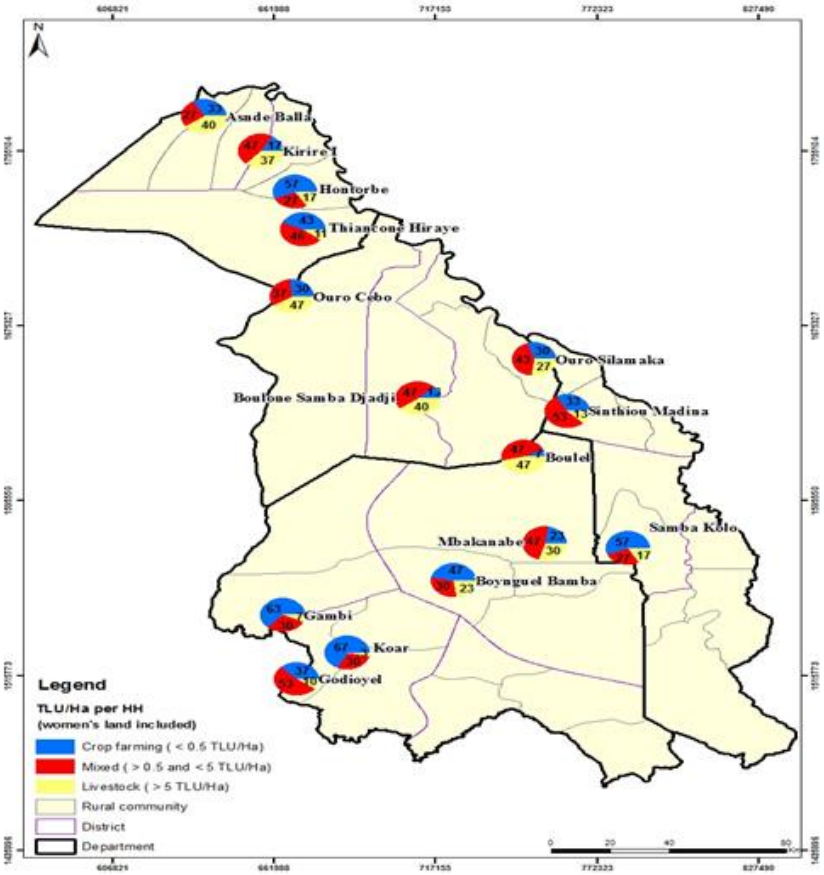
PORTEFEUILLES DOMINANTS & UNITÉS DE BÉTAIL TROPICAL

DEFINITION: UNITE DE BETAIL TROPICAL (TLU)/HA PAR MENAGE (TERRAINS DES FEMMES INCLUS)	
AG	< .5 TLU/Ha
MX	> .5 and < 5 TLU/Ha
LV	> 5 TLU/Ha

Type de systeme	Proportion Ménages
AG	36.2
MX	39.3
LV	24.6

COMPOSITION DES PORTEFEUILLES

Complexité de la distribution des moyens d'existance.



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CONTEXTE & APERÇU DES MOYENS D'EXISTENCE

FACTEURS DE STRESS NON CLIMATIQUES

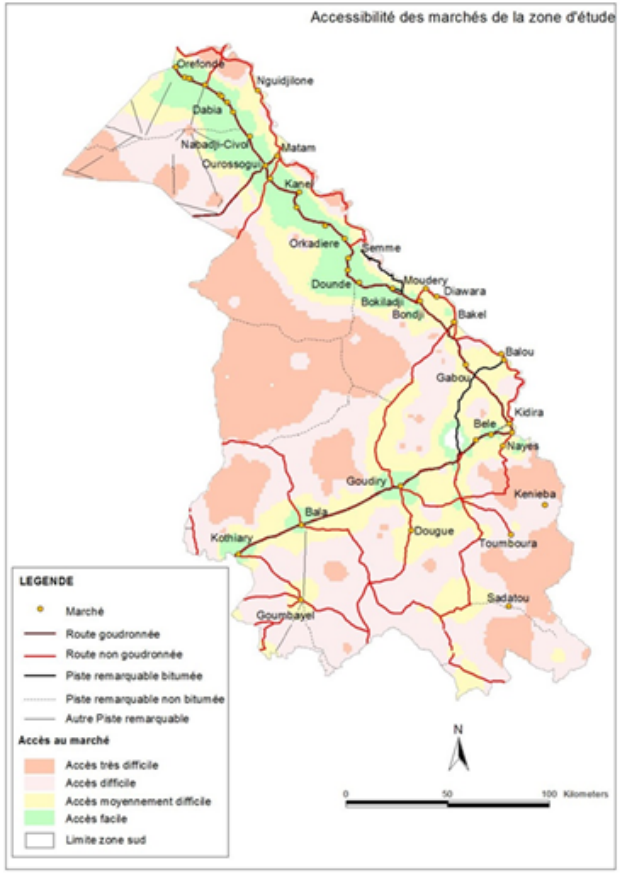
- Croissance Démographique vertigineuse
- Manque d'Infrastructures physiques & Sociales
- Bas Niveau d'Education
- Malnutrition & insécurité alimentaire
- Isolement
- Impuissance face aux pouvoirs

COMPOSITION DES PORTEFEUILLES

ROLE CROISSANT DU MARCHE

A plusieurs reprises, au cours des discussions de groupe, les paysans ont insisté pour dire que:

« Autrefois, l'essentiel de la nourriture était produite localement, aujourd'hui il faut s'approvisionner au marché; c'est ce qui rend les conditions de vie très difficiles. L'argent est devenu le principal moyen de survie pour nos populations »



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- Capacités d'adaptation
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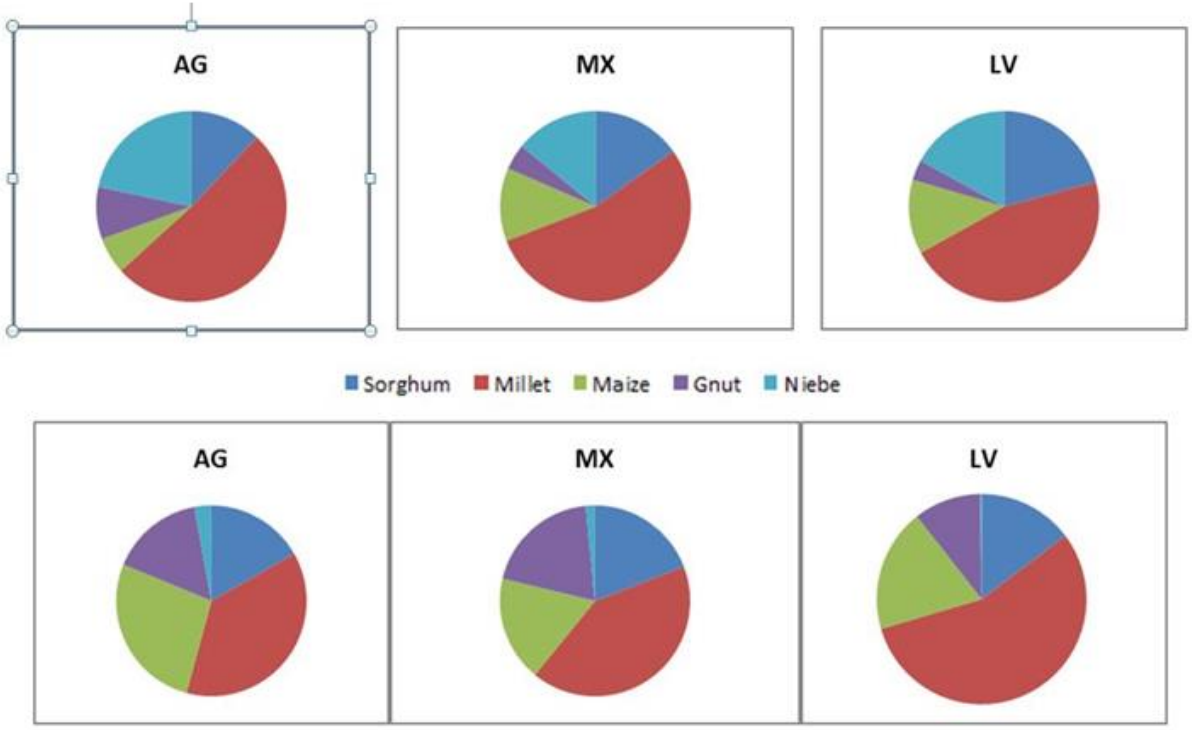
COMPOSITION DES PORTEFEUILLES

Jongler avec les portefolios pour reduire le niveau de sensibilite: agriculture

Example: Certaines variété de niébé produisent mieux dans des conditions sèches et sont utilisées au nord.
Le maïs ayant des besoins en eau plus importants, pousse mieux au sud.



Portfolios de culture: North en Haut, Sud en Bas

COMPOSITION DES PORTEFEUILLES

Jongler avec les portefolios pour reduire le niveau de sensibilite: elevage

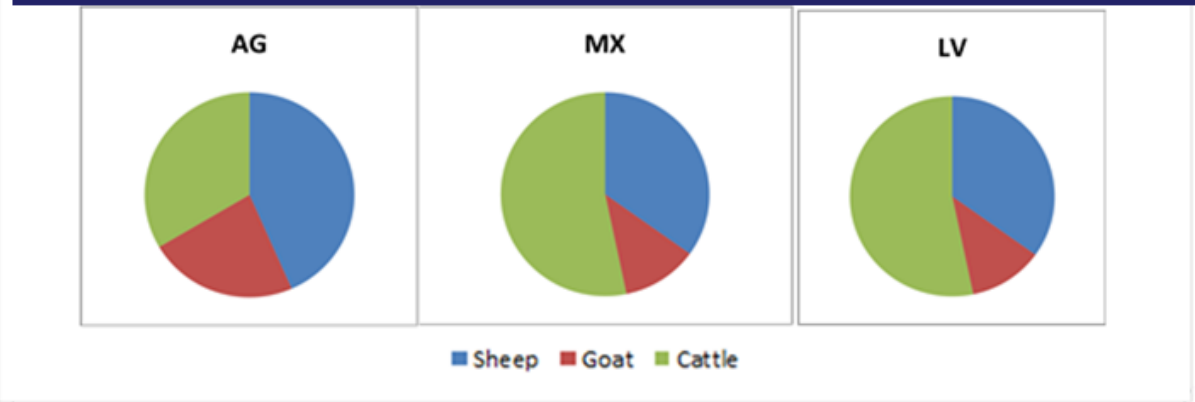
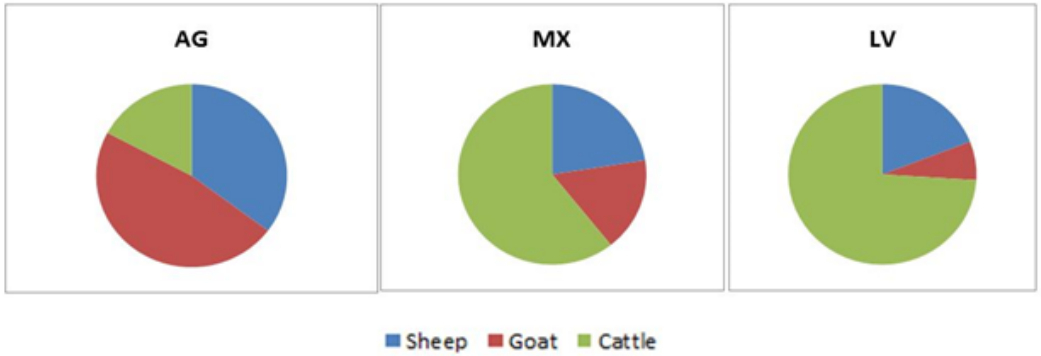


FIGURE 8: PORTFOLIOS OF CATTLE, SHEEP, AND GOATS: SOUTH



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CAPACITÉS D'ADAPTATION

2 TYPES DE CAPACITE D'ADAPTATION

AC1: Actifs du Ménage reflétant 5 types de capital: Humain, naturel, physique, social et financier

AC2: Ce sont des indicateurs de facteurs de stress: les maladies chroniques, Insécurité Alimentaire, diminution des ressources productives.

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CAPACITÉS D'ADAPTATION

AC1 - CINQ TYPES DE CAPITAL ANSLYSES

Humain:	• la santé, la nutrition, le travail, l'éducation
Naturel:	• les champs, les pâturages, l'eau
Physique:	• biens, machines/outils agricoles
Social:	• associations d'agriculteurs, les réseaux de parenté, les services de vulgarisation, les programmes de développement
Financier:	• le revenu (y compris les transferts, la migration saisonnière, la vente des récoltes, emploi rémunéré)

CAPACITÉS D'ADAPTATION

Indicateurs collectés

Asset Class	Variable Name	Description	North			South		
			AG	MX	LV	AG	MX	LV
Human	Dependency ratio	Ratio (non-producers/producers)	1.4	1.2	1.5	1.3	1.3	1.3
Human	Education Score	Avg. HH ed. score (age-adjusted)	0.18	0.15	0.13	0.17	0.1	0.15
Social	Social capital index	Index	6.73	14.14	9.07	10.73	12.97	10.18
Physical	Asset Index	Index	631	813	825	763	1047	1274
Physical	Housing Index	Index (walls, roof, floor materials)	94.27	102.04	105.92	73.88	114.91	126.11
Physical	Water quality	%HH w/ piped in water	14.5	14.8	12.3	7	4.2	6.7
Natural	Land quality (walo, jeri)	% HH that farm walo	16.1	29.6	26.2	1	0	0
Natural	Land quantity	Ha per adult equivalent	1.5	0.72	0.25	1.41	0.89	0.42
Natural	Market vegetables	% HH producing	0.03	0.06	0.05	0.04	0.07	0.05
Natural	TLU/Adult Equivalent	number	0.17	1	2.8	0.15	1.3	5.02

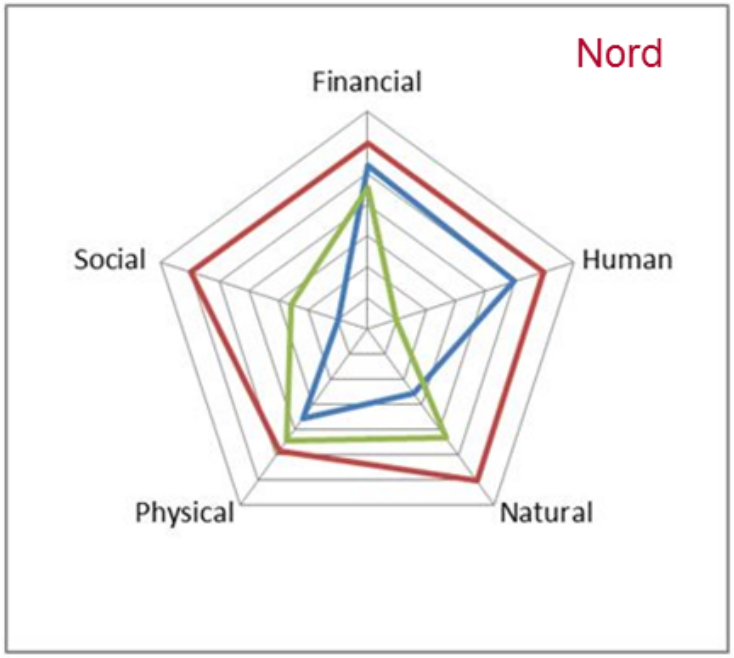
EXPOSITION, SENSINBILITE

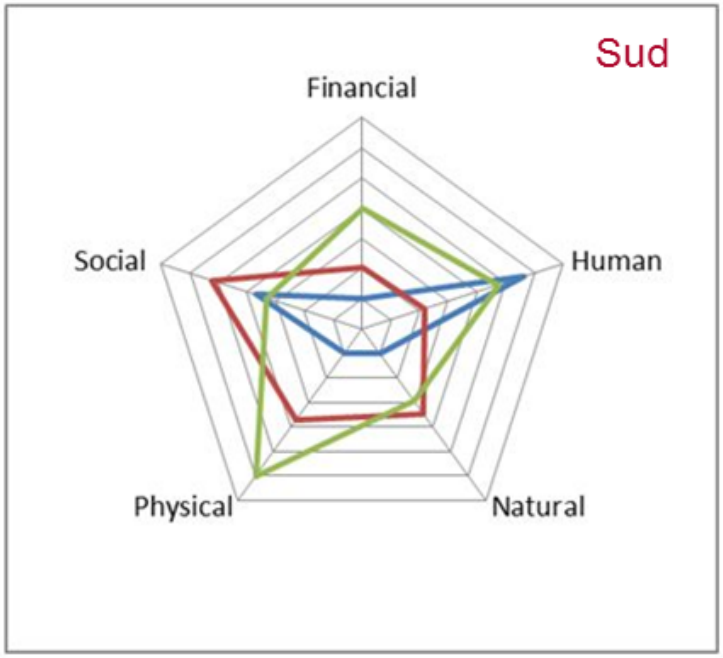
Méthodes

Indicateurs → Re-echelonnement sur l'intervalle [0 1] → Représentation des 5 capitaux pour les trois types de moyens d'existence

CAPACITÉS D'ADAPTATION

Capacité d'adaptation des ménages par zones et moyens de subsistance





AG MX LV

Plus on est loin du centre plus on a de la capacité d'adaptation

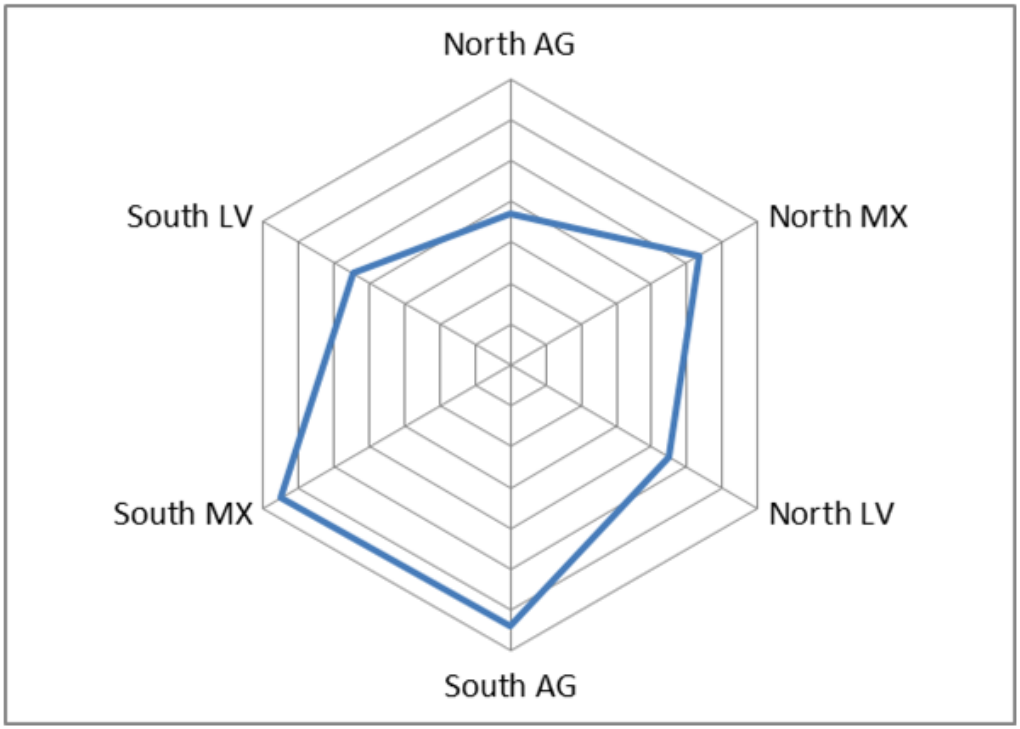
CAPACITÉS D'ADAPTATION

AC2 - Vulnérabilité et dégradations de conditions de production

Variable Name	Description	North			South		
		AG	MX	LV	AG	MX	LV
Food insecurity	Avg. number of months	6.30	6.20	5.10	4.40	3.60	2.80
Lost days due to illness or injury	%HH	46.80	51.90	43.10	58.00	60.00	40.00
Dietary diversity and quality (higher less diverse)	number	28.00	31.00	29.00	41.00	36.00	37.00
Chronic illness	%HH	66.10	66.70	58.50	78.00	76.80	66.70
Refused access to livestock resources	%HH	6.50	4.90	7.70	6.00	6.30	4.40
Sheep and goats herd decreased in the past 10 years	%HH	61.30	75.00	68.10	26.60	48.60	53.90
Cattle herd decreased in the past 10 years	%HH	24.20	66.10	63.60	25.30	57.60	62.20
Lost land in the past 10 years	%HH	22.60	21.00	20.00	30.00	24.20	24.40
Not enough land currently	%HH	32.30	44.40	44.60	65.00	62.10	68.90

CAPACITÉS D'ADAPTATION

AC2 INDICATEURS DE STRESS PAR ZONE & SYSTEMES DE SUBISTANCE, MOYENNES AJUSTEES



Plus on est loin du centre moins on a de la capacité d'adaptation

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- **Tendances et quelques axes de conclusion**

TENDANCES ET QUELQUES AXES DE CONCLUSION

RESULATS SAILLANTS DECOULANT DU CONTEXTE

1. Les communautés rurales de la zone d' étude font face à d' énormes défis dont des ressources limitées, des taux de scolarisation remarquablement bas et des taux de migration élevés.
2. En outre, elles sont confrontées à de nombreux défis au niveau de leurs systèmes de production, avec des ressources naturelles qui se détériorent, un accès limité aux intrants et au crédit, un réseau routier insuffisant et un système de marché sous-développé.
3. Selon les enquêtes, Les communautés de cette zone reçoivent rarement l'aide des institutions externes.

TENDANCES ET QUELQUES AXES DE CONCLUSION

STRATEGIES ADAPTIVES MENTIONNEES DANS LES FOCUS GROUPES

- Mobilité
- Innovation en elevage et en agriculture
- Marchés
- Stockage
- Diversification
- Solidarité communautaire

TENDANCES ET QUELQUES AXES DE CONCLUSION

Moins d'élevage de prestige. Commercialisation et concentration accrue des animaux: achat de fourrage, Embauche, éleveurs professionnels..

Destruction massive des forêts surtout au sud, feux de brousses, **pressions d'eleveures venant d'ailleurs.**

Nouvelles explorations et innovations dans l'agriculture et l'elevage: nouvelles varietes de cultures et despeces animales, augmentation du maraichage, usage de la culture attelee, jonglage avec les dates de semis, augmentation des superficies cultivees surtout au sud, etc..

TENDANCES ET QUELQUES AXES DE CONCLUSION

Dichotomie exclusive agriculture/elevage remise en question par les réalités actuelles du milieu. Une image plus complexe se degage.

Les ménages du Nord combinant l'agriculture et l'elevage sont relativement en meilleur conditions que tous les autres, suivis par les ménages dans le Sud qui dépendent principalement de l'élevage.

En règle générale, ménages dépendant exclusivement de l''agriculture et se trouvant dans le sud sont les plus vulnérables

PERCEPTIONS DES HABITANTS DES CHANGEMENTS CLIMATIQUES ET DES STRATÉGIES D'ADAPTATION

- Les conditions de vie deviennent ainsi assez difficiles. Nous remarquons la disparition progressive des activités de production agricole au détriment de nouvelles alternatives de survie: migration, élevage en tant que business pour ceux qui en ont les moyens, etc.

- Plusieurs informant clés ont note qu' il y a des températures très enlevées, des phénomènes de vent de sable et une dégradation continue du couvert végétal. Autrefois la saison des pluies durait au moins 3-4 mois, aujourd'hui non seulement les pluies sont irrégulières mais la saison des pluies est devenue très courte. La zone est aussi marquée par la disparition continue des arbres». Harouna Ndongo .

Merci
Pour
Votre
attention
:)

Thank You

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ARCC African & Latin American Resilience to Climate Change

A USAID funded project implemented by TetraTech/ARD

ÉVALUATION DE LA VULNÉRABILITÉ DU SÉNÉGAL FACE AU CHANGEMENT CLIMATIQUE ET ANALYSE DES SOLUTIONS

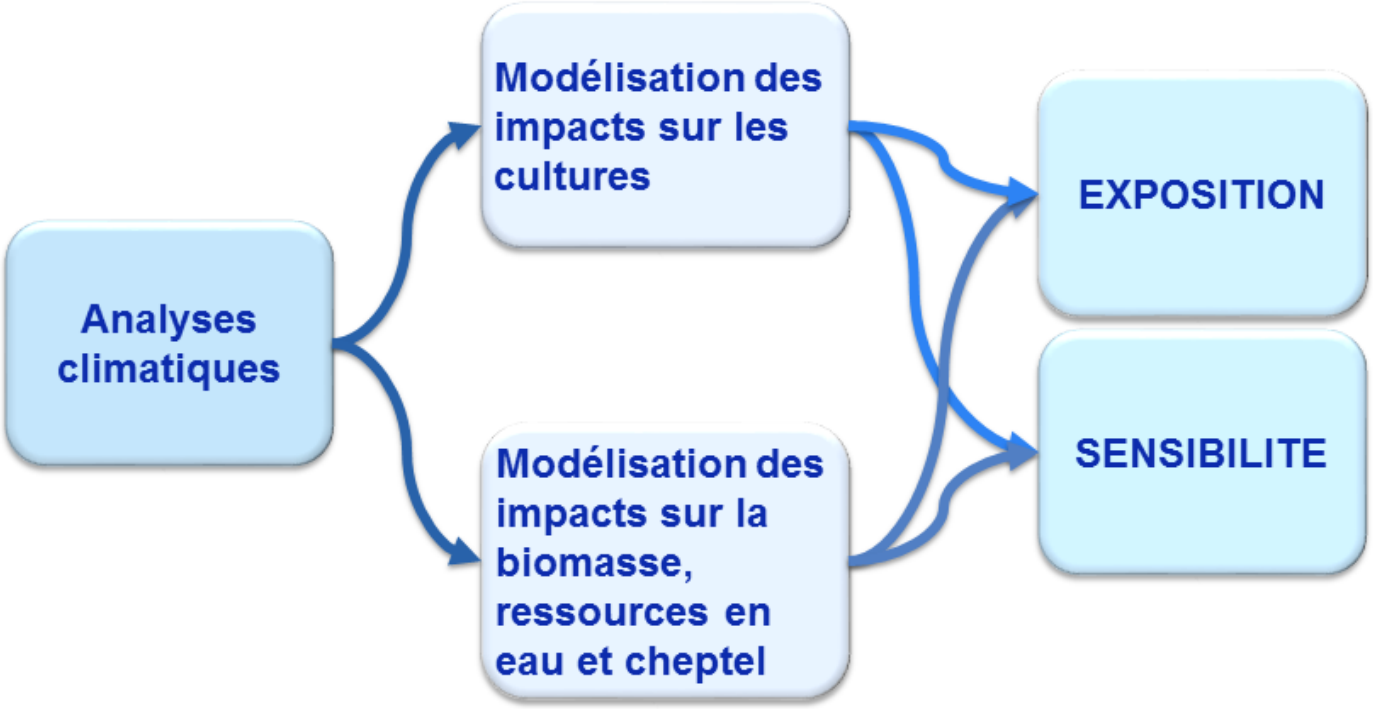
EXPOSITION et SENSIBILITÉ

S. Trzaska – CIESIN, Columbia University, New York, USA
M. Diop, B. Sarr – ISRA, Bambey, Senegal
G. Faye et collègues – CSE, Dakar, Senegal

Atelier de restitution et hiérarchisation des recommandations, Dakar, 15 septembre 2014

ELEMENTS DE L'ETUDE

ELEMENTS DE L'ETUDE

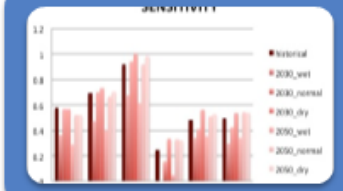


PLAN DE LA PRESENTATION

Analyses climatiques

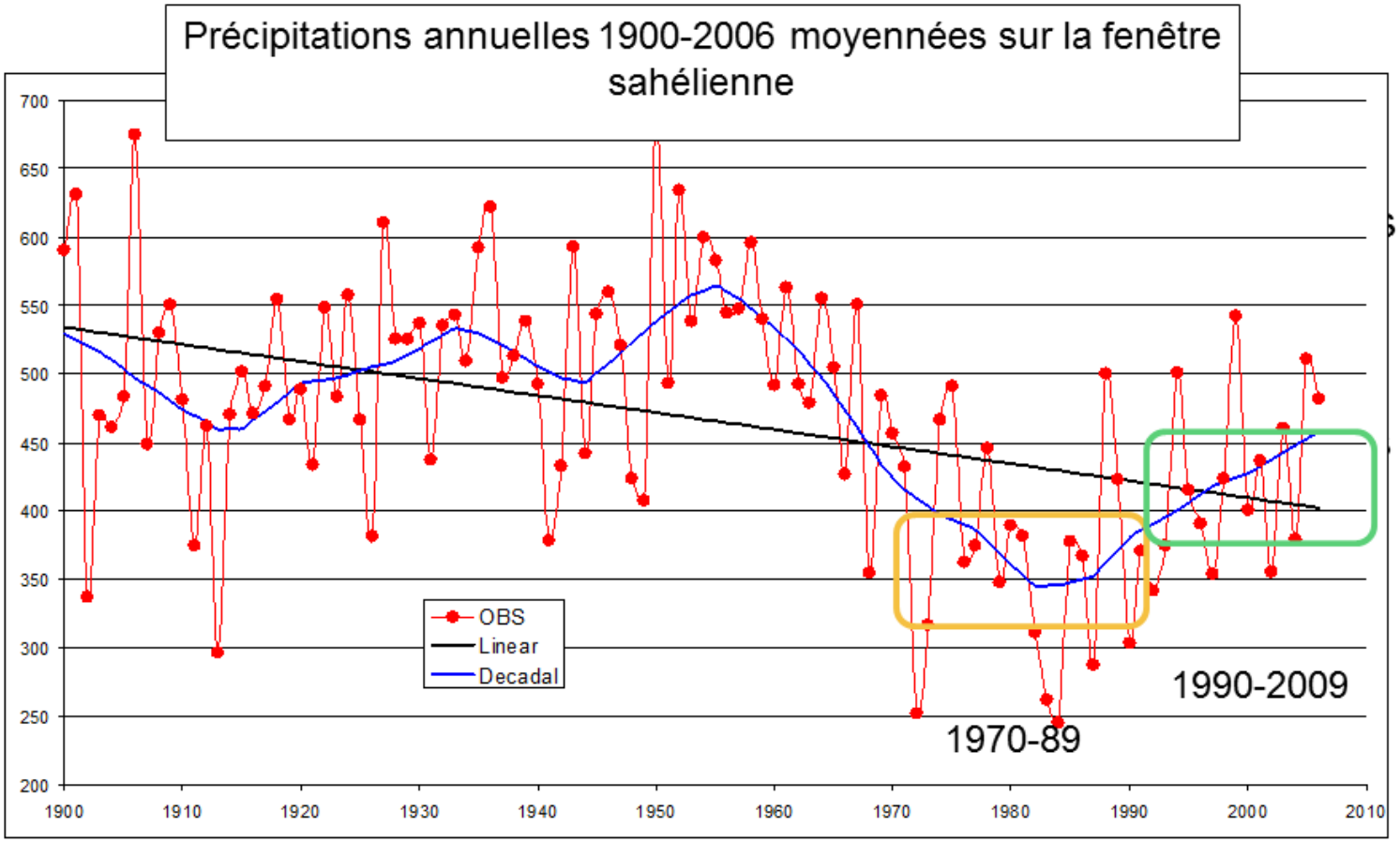
Modélisation des impacts du climat sur les cultures

Modélisation des impacts du climat sur la biomasse, ressources en eau et cheptel



Exposition et Sensibilité

ANALYSES CLIMATIQUES

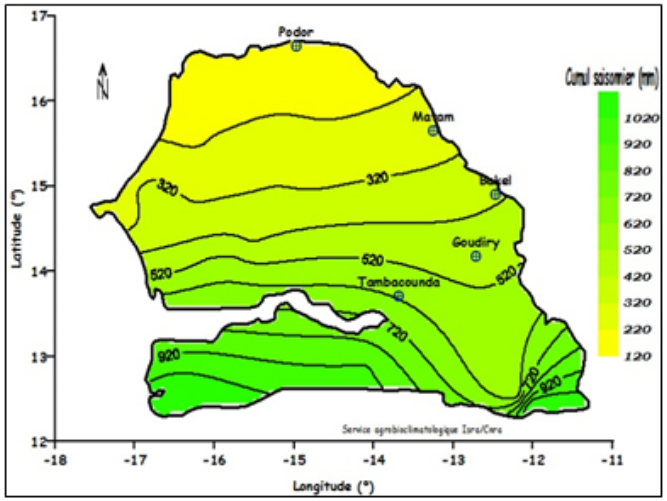


ANALYSES CLIMATIQUES

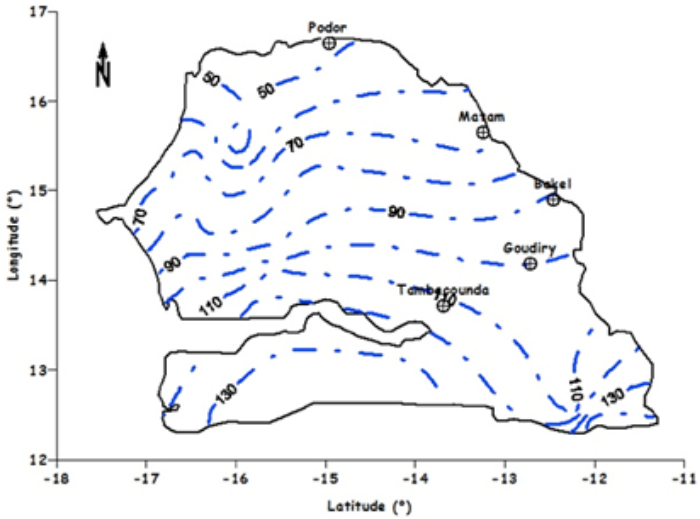
Historiques

- Pluies et température
- 5 station: Goudiry, Bakel, Matam, Podor, Tambacounda
- Caractéristiques saisonnières et mensuelles
- Caractéristiques intra-saisonnières: début/fin de la saison, séquences sèches, évènements extrêmes
- Moyennes sur 1970-2009
- Variabilité: amplitudes, changements entre périodes etc.

Précipitations annuelles



Durée de la saison des pluies



Projections

- 10 Modèles de Circulation Générale du CMIP5
- Données mensuelles pour 2030 (2015-2045) et 2050 (2035-2065)
- Deux scenarios RCP4.5 et RCP8.5
- Correction des biais sur la base des données historiques
- Désagrégation spatiale et temporelle
- Comparaison des moyennes, variabilité etc. a la période 1990-2009
- Sélection des modèles sec, moyen et humide

Modèles utilisés

Model	CanESM2	CCSM4	CNRM-CM5	CSIRO-Mk3-6-0	GISS-E2-R	HadGEM2-ES	MIROC-ESM	MIROC5	MPI-ESM-LR	MRI-CGCM3
Country of origin	Canada	USA	France	Australia	USA	UK	Japan	Japan	Germany	Japan
Lab	CCCMA	NCAR	CNRM-CERFACS	CSIRO-QCCCE	NASA GISS	MOHC	MIROC	MIROC	MPI	MRI
Res latxlon	2.8x2.8	0.9x1.25	1.4x1.4	1.87x1.87	2x2.3	1.25x1.87	2.81x2.81	1.4x1.4	1.8x1.8	1.125x1.125

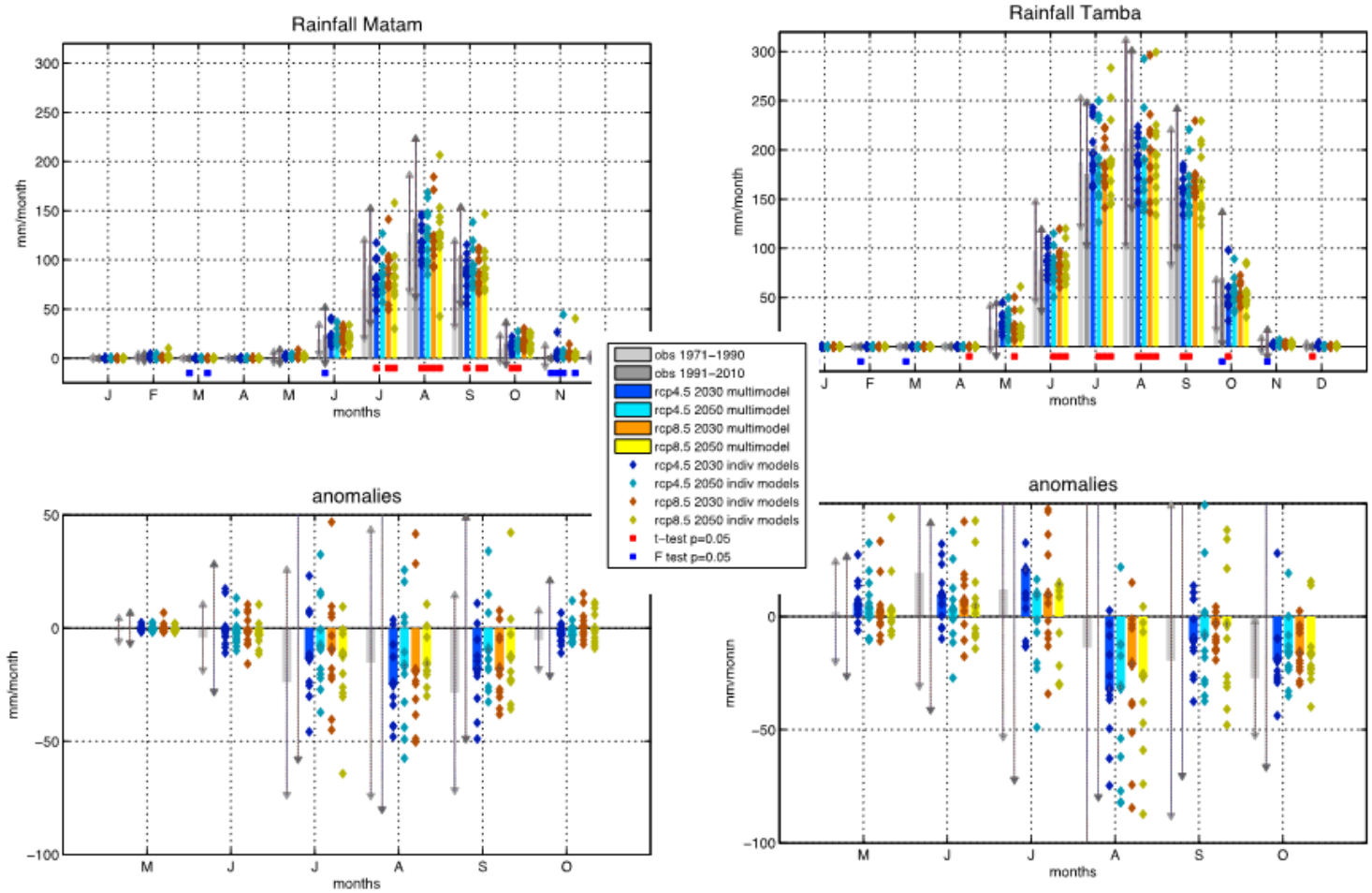
ANALYSES CLIMATIQUES

Résultats

- Tous les modèles simulent une augmentation de la température entre 2°C et 5°C
- Les changements des précipitations projetés sont plus variables entre les modèles

ANALYSES CLIMATIQUES

Résultats



MODELISATION DE L'IMPACT DU CLIMAT SUR LES CULTURES

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Objectifs

- Evaluer les variations historiques des rendements des différentes cultures en fonction de la période (1970-89 vs 1990-2009) et en années extrêmes (sèche ou humide)
- Evaluer les variations futures des différentes cultures pour 2030 et 2050, basées sur les modèles sec, normal et humide

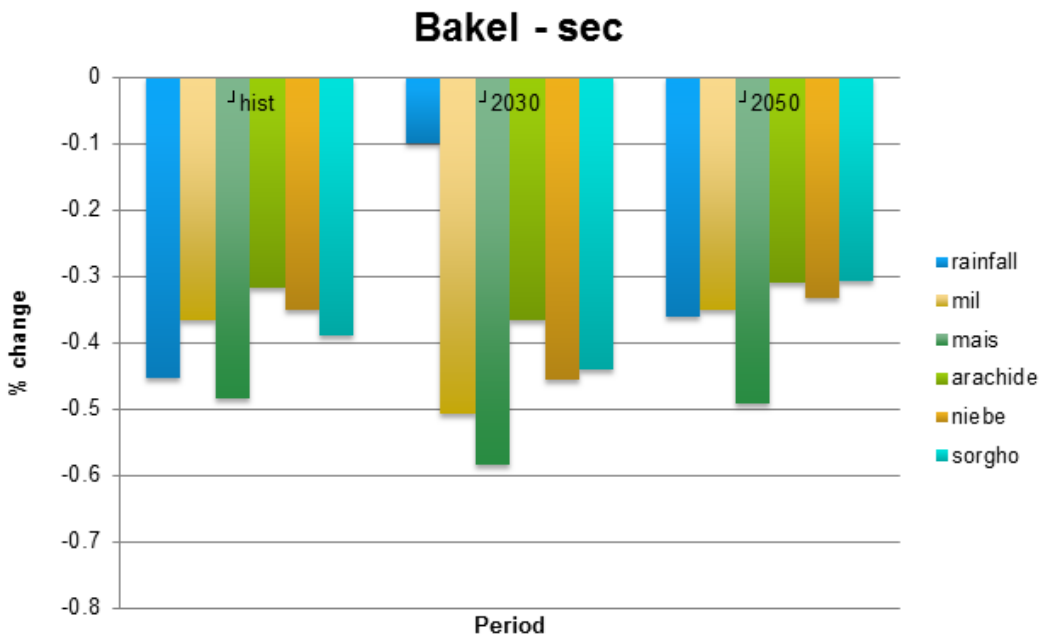
Outils

- CROPWAT: satisfaction des ressources en eau
- Cultures: mil, mais, arachide, niébé, sorgo

Approche

- Variations historiques : rendements année moyenne, sèche et humide de chacune des sous-périodes et
- Projections pour 2030 et 2050 : rendements année moyenne pour le modèle sec, moyen et humide
- Anomalies par rapport à l'année 1998, considérée comme référence (année moyenne période récente)

Résultats: station de Bakel, modèle sec



MODELISATION DE L'IMPACT DU CLIMAT SUR LA BIOMASSE, LES RESSOURCES EN EAU ET LE CHEPTEL

USAID FROM THE AMERICAN PEOPLE

Objectifs

- Evaluer les variations historiques de biomasse, ressources en eaux et capacité de charge du cheptel en fonction de la période (1970-89 vs 1990-2009) et en années extrêmes (sèche ou humide)
- Evaluer les variations futures de biomasse, ressources en eaux et capacité de charge du cheptel pour 2030 et 2050, basées sur les modèles sec, normal et humide

Outils

- Biomasse: modèle STEP (***S**ahelian **T**ranspiration **E**vaporation and **P**roduction model*) simule la dynamique de croissance de la végétation herbacée sahélienne et des variations de l'état hydrique du sol
- Ressources en eau: ennoiement des mares = F(pluie, température)
- Cheptel: relation statistique entre biomasse/eau disponible et capacité de charge

Approche

- Variations historiques : rendements année moyenne, sèche et humide de chacune des sous-périodes et
- Projections pour 2030 et 2050 : rendements année moyenne pour le modèle sec, moyen et humide
- Anomalies par rapport à l'année 1998, considérée comme référence (année moyenne période récente)

Résultats: anomalies de production de biomasse dans les 5 stations

TABLE 14: PROJECTED CHANGE IN BIOMASS RELATIVE TO HISTORICAL AVERAGE YEAR (1998)						
	2030			2050		
	dry	Normal	wet	dry	Normal	wet
	Δ %	Δ %	Δ %	Δ %	Δ %	Δ %
Podor	-0.41	-0.54	-0.17	-0.48	-0.29	-0.36
Matam	-0.31	0.16	0.25	-0.41	0.19	0.24
Bakel	-0.08	0.10	1.49	-0.12	-0.06	1.72
Goudiry	-0.24	-0.01	0.06	-0.33	-0.38	0.03
Tambacounda	-0.07	-0.09	0.17	0.02	0.12	0.59

EXPOSITION, SENSINBILITE

- Objectifs
  - Construire des indices à inclure dans les diagrammes de de vulnérabilité

- Définitions
  - Exposition: impact sur moyens de production
    - Ag: impact moyen sur l'ensemble des cultures
    - El: impact sur bétail/biomasse
    - Mix: 0.5 impact cultures+ 0.5 impact bétail/biomasse

  - Sensibilité: impact sur le portefeuille type
    - Cf. enquêtes ménages

EXPOSITION, SENSINBILITE

Méthodes

Impacts du climat sur les cultures, biomasse, eau et cheptel (en %)

→

Rééchelonnement changements en % sur l'intervalle [0 1]

→

Représentation des changements pour les trois types de moyens d'existence

- Historique
  - Différence période sèche vs période récente
  - Variation année sèche et année humide
- Projections
  - Différence 2030 (2050) vs période récente
  - Variations modèle sec, normal et humide

EXPOSITION

Prise en compte de l'impact du climat sur les cultures/bétail/biomasse

	Matam	Kanel	Bakel
Mil	-6%	-8%	-4%
Maïs	93%	109%	77%
Arachide	96%	100%	84%
Niébé	90%	101%	85%
Sorgho	93%	104%	86%

			Année sèche			HISTORICAL Année moyenne		Année humide			CV vs 1995 & 1998
			Δ vs 1995 & 1998	Δ 70	Δ 90	Δ (1979, 1987) vs (1995, 1998)	Δ vs 1995 & 1998	Δ 70	Δ 90		
mil	Matam		-56%	-59%	-51%	-34%	21%	20%	22%		37%
	Bakel		-37%	-40%	-29%	-1%	-1%	-2%	2%		21%
	Goudiry		-13%	-11%	-16%	-9%	-7%	-3%	-17%		11%
mais	Matam		-73%	-69%	-82%	-20%	14%	17%	8%		47%
	Bakel		-48%	-55%	-35%	-13%	-7%	-14%	7%		30%
	Goudiry		-25%	-28%	-20%	-8%	-6%	-1%	-18%		16%
arachide	Matam		-26%	-24%	-29%	-4%	14%	15%	11%		19%
	Bakel		-32%	-36%	-24%	-19%	-8%	-12%	1%		21%
	Goudiry		-13%	-19%	-3%	2%	3%	6%	-2%		10%

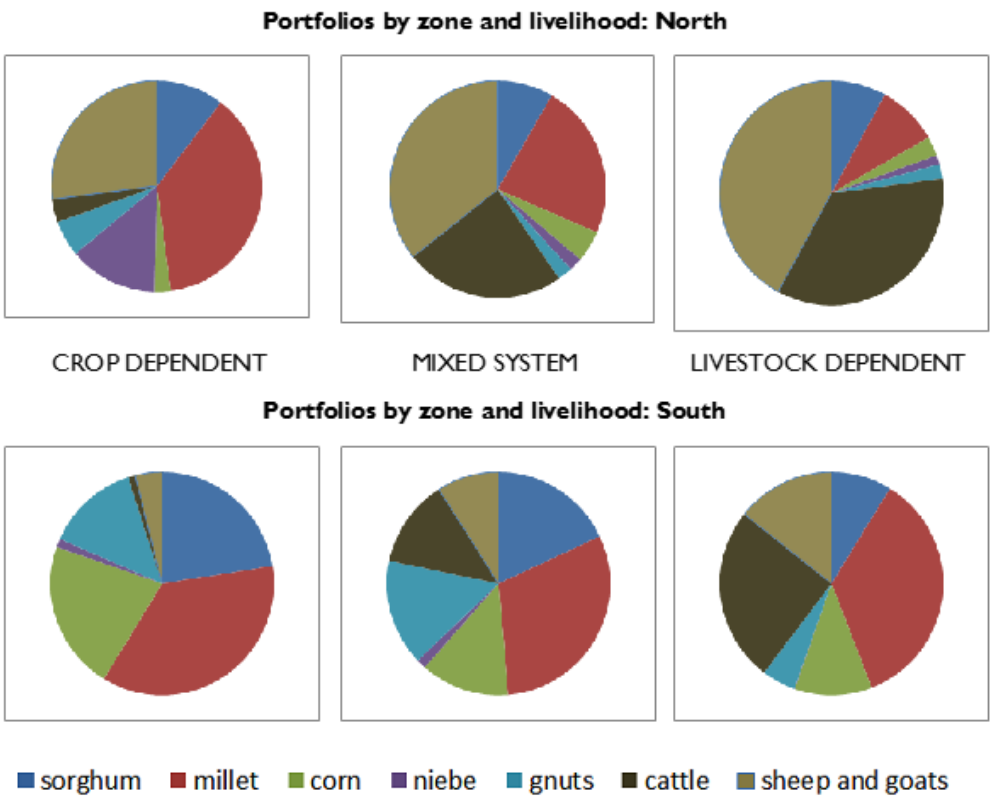
			Δ 1995 & 1998	Δ 1995 & 1999	Δ 1995 & 2000	Δ 1995 & 2001	Δ 1995 & 2002	Δ 1995 & 2003
mil	Matam		-8%	-15%	10%	0%	-4%	27%
	Bakel		-51%	-1%	0%	-35%	-35%	2%
	Goudiry		-31%	-6%	-15%	-12%	-1%	-7%
mais	Matam		-34%	-43%	72%	-24%	-30%	10%
	Bakel		-58%	-14%	5%	-49%	-56%	7%
	Goudiry		-36%	-2%	-10%	-19%	3%	-3%
arachide	Matam		-7%	-12%	4%	-3%	-5%	12%
	Bakel		-37%	-13%	1%	-31%	-32%	1%
	Goudiry		-10%	4%	0%	-10%	-3%	1%

EXPOSURE			CV & Change averaged						
			HIST	2030			2050		
			Année moyenne	sec	normal	humide	sec	normal	humide
N	al	AG	0.51	0.51	0.55	0.44	0.45	0.49	0.35
		MIX	0.70	0.76	0.73	0.54	0.72	0.70	0.48
	de	LV	0.89	1.00	0.92	0.65	1.00	0.91	0.61
S	al	AG	0.31	0.46	0.28	0.28	0.40	0.35	0.26
		MIX	0.39	0.39	0.31	0.14	0.34	0.39	0.15
	de	LV	0.48	0.32	0.33	0.00	0.29	0.43	0.03

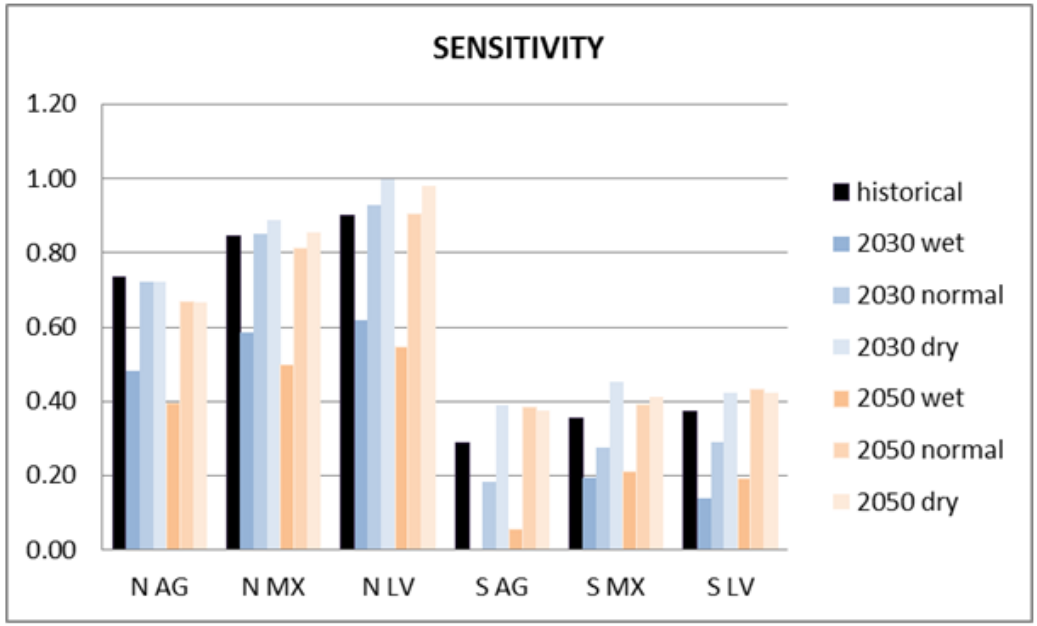
Echelle 0-1

Prise en compte du portefeuille des activités

FIGURE 8: IMPORTANCE OF CROPS AND ANIMALS IN LIVELIHOOD PORTFOLIOS



Résultats intégrés



RESUMÉ

APPROCHES

- Evaluation de l'exposition et de la sensibilité
- Analyses du climat historique et projeté dans 5 stations
- Modélisation des cultures, biomasse, ressources en eau et cheptel
- Evaluation de le sensibilité en fonction des portefeuilles des ménages dans les deux zones et les trois types de moyens de subsistance

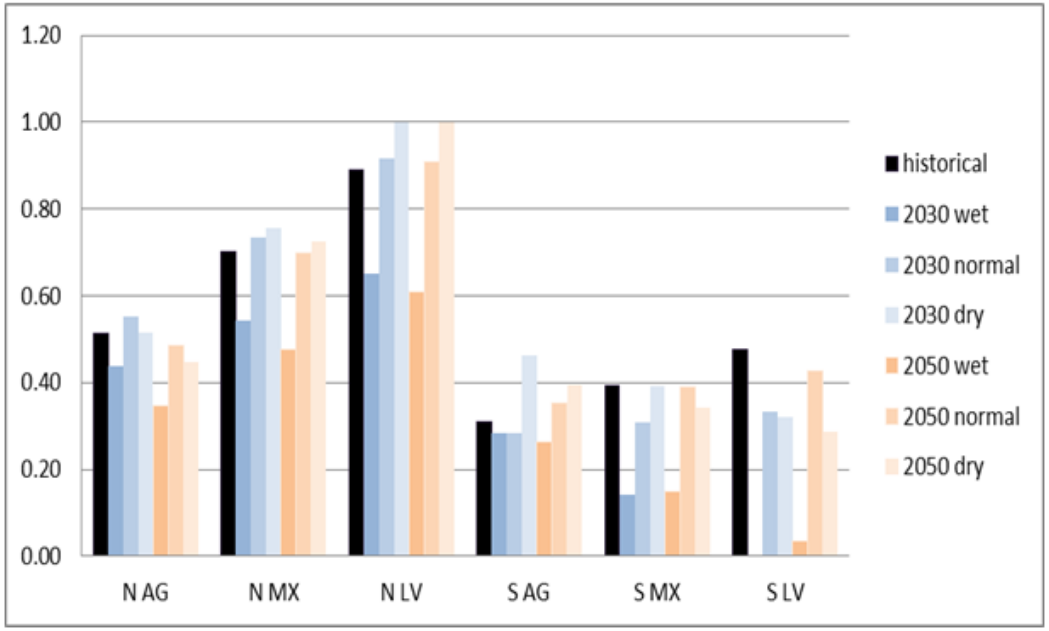
RESULTATS

- Projections climatiques indiquent:
  - une augmentation de le température (2°C à 5°C)
  - des changements dans les précipitations moins certains, mais une réduction vers les niveaux des années 1970-90 probable
- Exposition et sensibilité:
  - une plus forte exposition/sensibilité des ménages dans le nord quelque soit le type de moyens d'existence

☛Limitations:

- nombre réduit de simulations de rendements et capacité de charge
- les effets de la transhumance non pris en compte

Résultats intégrés



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EVALUATION DE LA VULNÉRABILITÉ AU CHANGEMENT CLIMATIQUE DANS L'EST DU SENEGAL

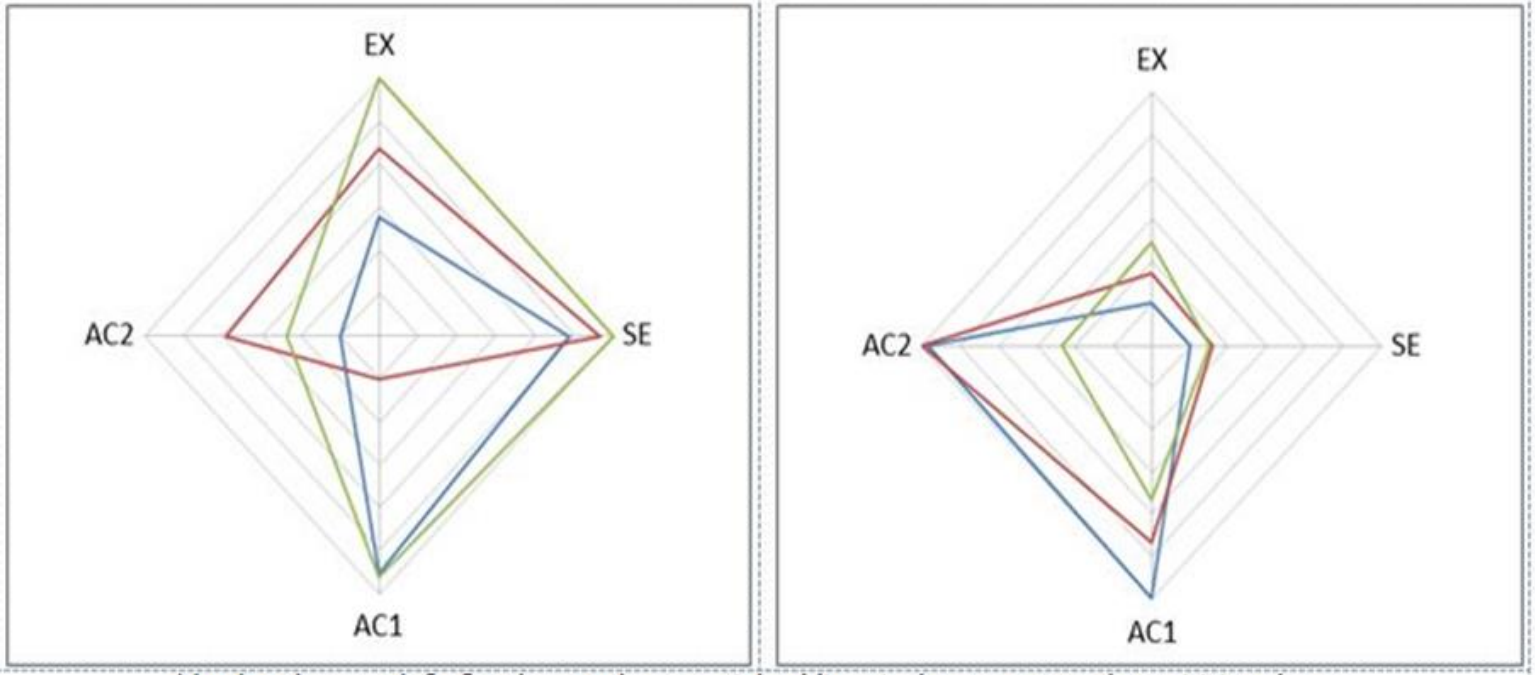
CONCLUSIONS ET RECOMMANDATIONS

CONCLUSIONS ET RECOMMANDATIONS

- Conclusions concernant la vulnérabilité
- Réponses locales à la vulnérabilité
- Liste des recommandations initiales

LA VULNÉRABILITÉ RELATIVE DES MOYENS DE SUBSISTANCE DANS LA ZONE D'ÉTUDE

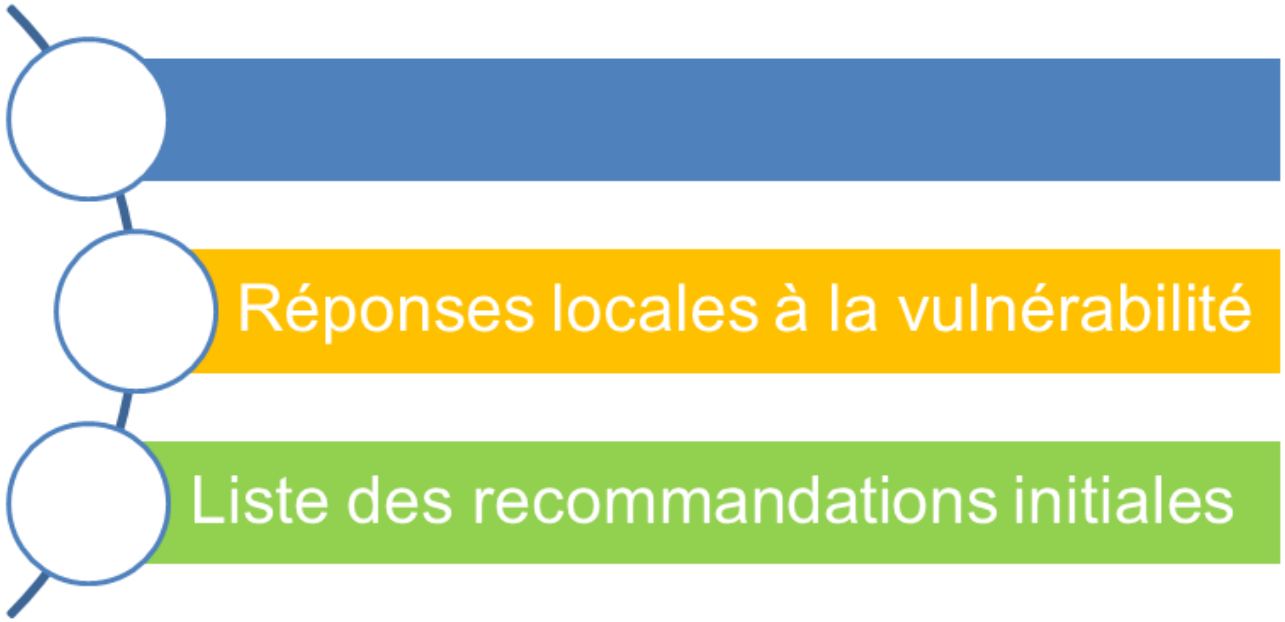
LA VULNÉRABILITÉ DES TROIS MOYENS DE EXISTANCE



North sub-zone, left. Southern sub-zone, right. Historical exposure and sensitivity above; 2050 normal exposure and sensitivity below.
(Farther from the center = greater vulnerability.)

AG MX LV

CONCLUSIONS ET RECOMMANDATIONS



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STRATÉGIES D'ADAPTATION DES MÉNAGES

- la mobilité
- les marchés
- le stockage
- la diversification
- la solidarité communautaire
- l'innovation en agriculture

LES TENDANCES QUI SONT SUSCEPTIBLES DE CONTINUER

Pression accrue sur les terres et des pâturages

Une augmentation:

- Des terres cultivées dans les zones nouveaux et marginales, y compris les bas fonds et les jardins maraîchers
- De l'élevage dans le sud, ainsi qu'une augmentation de la transhumance vers la sud
- Des clôtures des champs dans le sud, la disponibilité réduite des résidus de récolte, la demande accrue pour les aliments achetés
- Des conflits sur l'accès aux pâturages pour le bétail

LES TENDANCES QUI SONT SUSCEPTIBLES DE CONTINUER

Les ménages vont continuer à diversifier leurs investissements

Nous pouvons nous attendre à la poursuite:

- Des investissements dans l'agriculture des cultures, mais probablement diminution des investissements dans le maïs et l'arachide production dans le Nord
- De la pression de migrer, même si d'entreprendre le travail non qualifié
- De l'investissement dans les petits ruminants
- Dans le fourrage

CONCLUSIONS ET RECOMMANDATIONS

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RECOMMANDATIONS INITIALES

1. Contribue a promouvoir le maraîchage et la production de cultures de niche, comme l'apiculture
2. Renforcer les systèmes existants afin d'augmenter l'accès des producteurs a la diversité de semences de qualité.
3. Clarifie les droits fonciers dans les couloirs de passage pour les animaux
4. Contribue a promouvoir des techniques pour augmenter la production de fourrage
5. Renforce les systèmes d'Alerte Précoce en prévision des changements climatiques.
6. Augmente la prise de conscience et les capacités des communautés pour faire face aux effets des changements climatiques et a leur capacité des gestion des risques.
7. Contribue a une meilleure intégration des systèmes de production lies a l'agriculture et l'élevage.
8. Développe l'irrigation a petite échelle
9. Renforce la promotion de pratiques de terrain en matière de gestion efficace des eaux de ruissellement
10. Renforce le cadre juridique et institutionnel pour la gestion équitable et durable des ressources naturelles communes, telles que les plaines, les pâturages et les forêts.
11. Met en place des instruments pour un assurance bétail.
12. Renforce les services vétérinaires
13. Investit sur la recherché pour la promotions de variétés de cultures adaptées aux changements climatiques.

CONCLUSIONS AU-DELÀ DE LA ZONE D'ÉTUDE

- Précipitations susceptibles de revenir à des niveaux années 70-80
- Incertitude spatiale et temporelle
- La variabilité de l'augmentation des précipitations, les événements extrêmes
- Augmentation de la fréquence des «mauvaises» années pour les cultures et le bétail

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SENEGAL CLIMATE CHANGE VULNERABILITY ASSESSMENT AND OPTIONS ANALYSIS: ANNEXES Y – CC

SEPTEMBER 2014

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ARCC

African and Latin American
Resilience to Climate Change Project

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MULTI-CRITERIA ANALYSIS INSTRUCTIONS AND RESULTS IN FRENCH AND ENGLISH

MCA INSTRUCTIONS – ENGLISH

PLEASE SCORE THE FOLLOWING RECOMMENDATIONS FOR THE MULTI-CRITERIA ANALYSIS

Directions: Please read the following list of possible actions to take to reduce climate change vulnerability in eastern Senegal. After listening to today's presentations, please score them according to the scale in the table below. Your responses will be included in the afternoon discussions.

	OPTION	**SCORE (1-3)** **1= very good option** **2 = good option** **3 = least good option**
1	Promote market gardening and production of niche crops, like bee keeping	
2	Strengthen systems to increase producer access to diverse and high quality seeds	
3	Clarify tenure rights in livestock corridors and pasture	
4	Promote techniques to increase fodder production and collection	
5	Strengthen national climate and early warning information system	
6	Raise awareness and capacity of communities regarding climate change and disaster management	
7	Promote the integration of livestock raising in crop agriculture systems	
8	Promote small and micro irrigation	
9	Promote field practices to strengthen the management of runoff water	
10	Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest.	
11	Establish instruments for crop and livestock insurance.	
12	Reinforce veterinary services	
13	Invest in research for climate-adapted crop varieties	

OPTION EVALUATION CRITERIA

Criteria	**Definition of range (1-5)**
Adaptive -- mitigates rural producer climate risk	1 = does not mitigate rural producer climate risk 5 = effectively mitigates rural producer climate risk
Robust – flexible over time, addresses range of challenges and development objectives	1 = addresses one limited challenge or development objective 5 = addresses a range of possible climate impacts, and/or can be adapted over time to new threats
Equitable – positive impact on vulnerable groups	1 = targets groups that are not most vulnerable 5 = targets groups that are most vulnerable
Feasible –technically and institutionally viable; aligned with public support, government and donor policy and strategies	1 = does not align with government policy, political or public will and/or is not technically or institutionally viable. 5 = strongly aligned with government policy, political and/or public will and/or and is technically and institutionally viable
Efficient – value of outputs relative to effort	1 = costly relative to expected impact 5 = excellent impact expected relative to cost

EVALUATION MATRIX

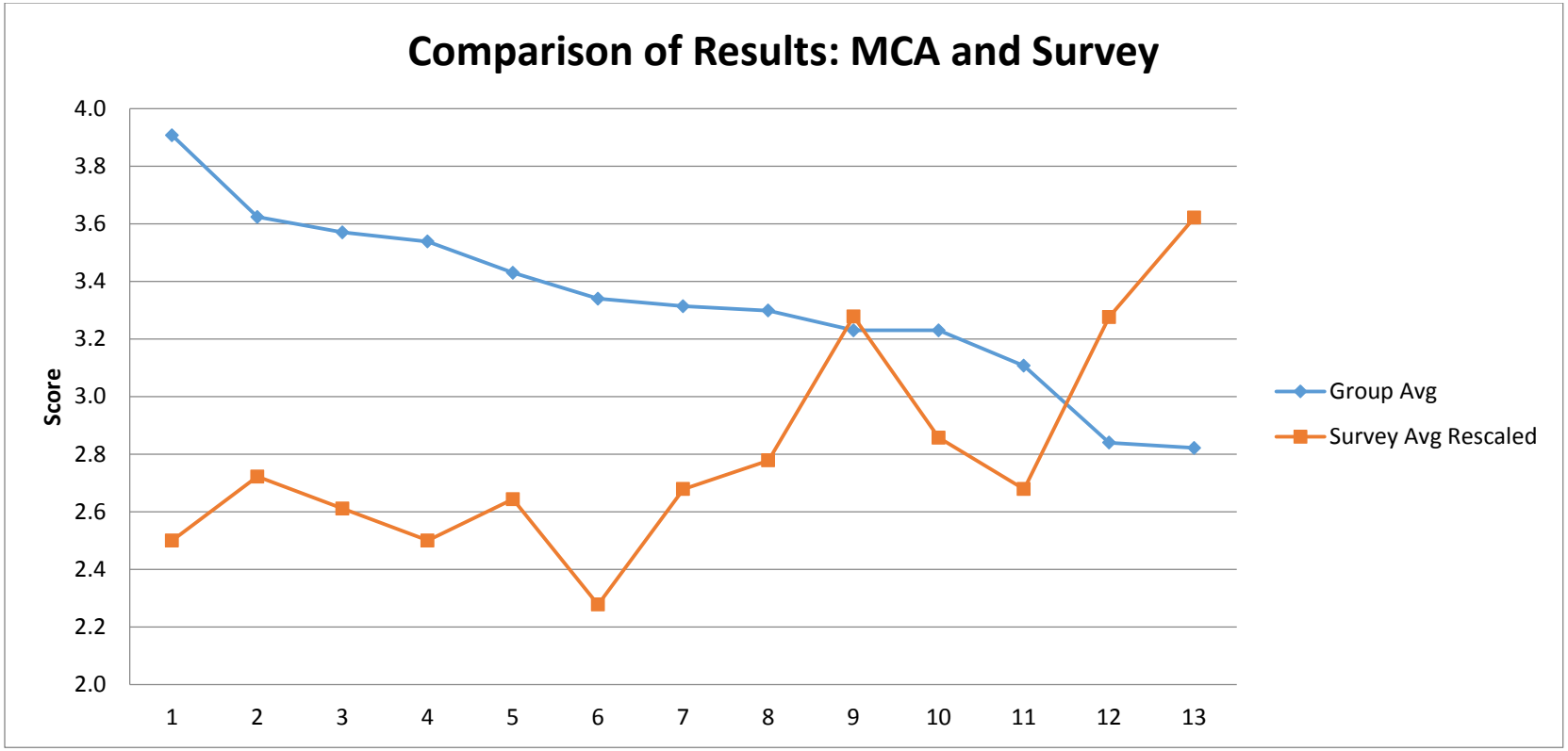
		C1	C2	C3	C4	C5
	OPTION	ADAPTIVE	ROBUST	EQUITABLE	FEASIBLE	EFFICIENT
1	Promote market gardening and production of niche crops, like bee keeping					
2	Strengthen systems to increase producer access to diverse and high quality seeds					
3	Clarify tenure rights in livestock corridors and pasture					
4	Promote techniques to increase fodder production and collection					
5	Strengthen national climate and early warning information system					
6	Raise awareness and capacity of communities regarding climate change and disaster management					
7	Promote the integration of livestock raising in crop agriculture systems					
8	Promote small and micro irrigation					
9	Promote field practices to strengthen the management of runoff water					
10	Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest.					
11	Establish instruments for crop and livestock insurance.					
12	Reinforce veterinary services					
13	Invest in research for climate-adapted crop varieties					

Guidelines for the Group Work

1. Identify a reporter to record and present your group's work.
2. Identify a moderator to facilitate your group's work.
3. Distribute the materials to the members of the group.
4. Individually, read the criteria and the options. On the evaluation sheets, score the options individually, following the criteria guidelines.
5. As a group, share the scores one at a time. The reporter will record the scores on the flip chart and calculate the average score for each cell and for each option.
6. Review and discuss the results of the scoring process. Note the options which received divergent scores from different members of the group. Discuss the reasons different participants gave different scores to options. If, after discussion, the group wants to revise the scores for any option, you may do so.
7. Note on the second flip chart paper any observations on the process. Was it difficult? Did the discussions influence the decisions of members of the group? How did the process modify your perception of how to value the different options?

MCA RESULTS – ENGLISH

	OPTIONS TO SUPPORT ADAPTATION	G1	G2	G3	Group Avg	Survey Avg Rescaled	MCA Ranking	Survey Ranking
6	Raise awareness and capacity of rural communities regarding climate change and disaster management	4.2	3.7	3.9	3.9	2.5	1	11
5	Strengthen national climate and early warning information system	3.7	3.4	3.9	3.6	2.7	2	6
2	Strengthen systems to increase producer access to diverse and high quality seeds	3.8	3.2	3.7	3.6	2.6	3	10
7	Promote the integration of livestock raising in crop agriculture systems	3.7	3.4	3.5	3.5	2.5	4	12
8	Promote small and micro irrigation	3.7	3.1	3.5	3.4	2.6	5	9
13	Invest in research for climate-adapted crop varieties	3.8	2.3	4.0	3.3	2.3	6	13
1	Promote market gardening and production of niche crops, like bee keeping	3.7	2.9	3.4	3.3	2.7	7	7
9	Promote field practices to strengthen the management of runoff water	3.3	3.3	3.4	3.3	2.8	8	5
10	Strengthen the legal and institutional framework for equitable and sustainable management of common natural resources, such as lowlands, pasture and forest.	3.4	3.0	3.3	3.2	3.3	10	2
4	Promote techniques to increase fodder production and collection	3.7	3.0	3.0	3.2	2.9	9	4
12	Reinforce veterinary services	3.5	2.8	3.1	3.1	2.7	11	8
3	Clarify tenure rights in livestock corridors and pasture	3.4	2.4	2.7	2.8	3.3	12	3
11	Establish instruments for crop and livestock insurance.	3.4	2.5	2.6	2.8	3.6	13	1


Comparison of Results: MCA and Survey
Score
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1
2
3
4
5
6
7
8
9
10
11
12
13
Group Avg
Survey Avg Rescaled

Working Group Observations

Group 1

- Number six (raise awareness) was clearly the strongest, and number nine (promote water management practices) the weakest. The rest fell in between.
- The insurance (11) and small and micro irrigation (8) choices would have scored more highly, except they scored very low on feasibility.
- The team needed more time to discuss the options, especially around how it would be implemented, and in particular the scale of the intervention – if it was to be implemented as a policy or institutional activity, or at the scale of the producer through extension. As this makes a difference in the scores, it would have been useful if they could also note the reasoning behind them.

Group 2

- There was general agreement on the scoring of the options among team members.
- Greater clarity and agreement on the elements of the activity would have facilitated the discussion.
- 3, There should have been an additional step to the activity in which some of the results could have been weighted. [This step has been included in MCA activities in other contexts.]
- There was some discussion among group members concerning the meaning of some of the concepts used, both in the criteria and in the recommendations. It would have helped to clarify these definitions prior to group work.

Group 3

- They scored increasing accessibility of quality seeds (2) very high, but note that they should be short cycle multi-purpose seeds that provide for both food and forage.
- They note that an early warning system (5) is important, they ranked it 2nd, but also note that it needs to be accompanied by a complementary rapid response system.
- They were surprised themselves that, in a context of potential decreasing rainfall, they gave such low scores to the options related to water management (Questions 1, 8, and 9). [The ranks of these three options averaged across all three groups were: 7, 5, and 8, respectively.]

MCA INSTRUCTIONS – FRENCH

VEUILLEZ CLASSER LES RECOMMANDATIONS POUR « L'ANALYSE DES CRITERES MULTIPLES »

Instructions Pratiques: Veuillez lire la liste des actions possibles pour réduire la vulnérabilité aux changements climatiques à l'Est du Sénégal. Apres avoir écouté les présentations de ce matin, Veuillez attribuer le score que vous jugez le plus adéquat en fonction de l'échelle présentée dans le tableau ci-dessous. Vos réponses seront intégrées dans les discussions de cet après-midi.

	OPTIONS	**SCORE (1-3)** **1= Très bonne option** **2 = Bonne option** **3 = Moins bonne option**
1	Contribue à promouvoir le maraîchage et la production de cultures de niche, comme l'apiculture	
2	Renforcer les systèmes existants afin d'augmenter l'accès des producteurs à la diversité de semences de qualité.	
3	Clarifie les droits fonciers dans les couloirs de passage pour les animaux	
4	Contribue à promouvoir des techniques pour augmenter la production de fourrage	
5	Renforce les systèmes d'Alerte Précoce en prévision des changements climatiques.	
6	Augmente la prise de conscience et les capacités des communautés pour faire face aux effets des changements climatiques et à leur capacité de la gestion des risques.	
7	Contribue a une meilleure intégration des systèmes de production lies a l'agriculture et l'élevage.	
8	Développe l'irrigation à petite échelle	
9	Renforce la promotion de pratiques de terrain en matière de gestion efficace des eaux de ruissellement	
10	Renforce le cadre juridique et institutionnel pour la gestion équitable et durable des ressources naturelles communes, telles que les plaines, les pâturages et les forêts.	
11	Met en place des instruments pour une assurance bétail.	
12	Renforce les services vétérinaires	
13	Investit sur la recherché pour la promotions de variétés de cultures adaptées aux changements climatiques.	

LES CRITÈRES D'ÉVALUATION DES OPTIONS

Critères	**Définition de la Variation du Champ (1-5)**
Adaptif -- réduit les risques des producteurs ruraux face aux changements climatiques	1 = ne réduit pas du tout les risques des producteurs ruraux face aux changements climatiques 5 = réduit effectivement les risques des producteurs ruraux face aux changements climatiques
Robuste – souple & flexible au fil du temps, arrive à résoudre les défis et atteindre les objectifs de développement.	1 = arrive à peine à résoudre 1 défis ou 1 objectif de développement 5 = arrive à résoudre une multitude de problèmes liés aux impacts des changements climatiques et/ou peut être adaptée au fil du temps aux nouvelles menaces
Equitable – impact positif sur les groupes vulnérables	1 = cible les groupes vulnérables 5 = cible les groupes les plus vulnérables
Faisable (réalisable) – techniquement et institutionnellement viable; en phase avec les politiques nationales, le gouvernement et la politique des bailleurs de fonds et les stratégies	1 = ne s'aligne pas avec les politiques nationales et les préoccupations de la société civile et n'est pas viable sur les plans institutionnels et techniques. 5 = en parfait harmonie avec les politiques nationales et les préoccupations de la société civile et parfaitement viable sur les plans institutionnels et techniques
Efficient – Rapports couts/résultats aux efforts fournis	1 = très coûteux par rapport à l'impact attendu 5 = excellent impact attendu par rapport au coût

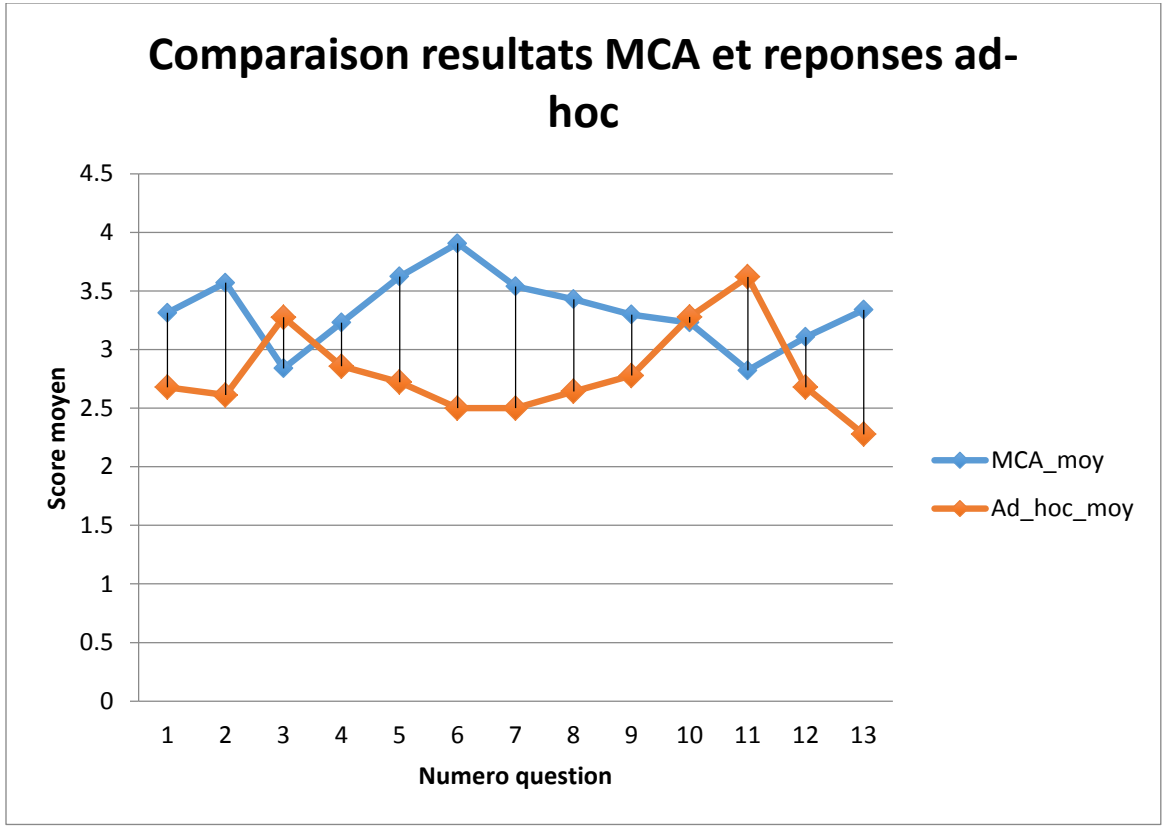
OPTION	C1	C2	C3	C4	C5	TOTAL
	ADAPTIF	ROBUSTE	EQUITABLE	REALISABLE	EFFICIENT	
1. Contribue à promouvoir le maraîchage et la production de cultures de niche, comme l'apiculture						
2. Renforcer les systèmes existants afin d'augmenter l'accès des producteurs à la diversité de semences de qualité.						
3. Clarifie les droits fonciers dans les couloirs de passage pour les animaux						
4. Contribue à promouvoir des techniques pour augmenter la production de fourrage						
5. Renforce les systèmes d'Alerte Précoce en prévision des changements climatiques.						
6. Augmente la prise de conscience et les capacités des communautés pour faire face aux effets des changements climatiques et à leur capacité de la gestion des risques.						
7. Contribue à une meilleure intégration des systèmes de production lies à l'agriculture et l'élevage.						
8. Développe l'irrigation à petite échelle						
9. Renforce la promotion de pratiques de terrain en matière de gestion efficace des eaux de ruissellement						
10. Renforce le cadre juridique et institutionnel pour la gestion équitable et durable des ressources naturelles communes, telles que les plaines, les pâturages et les forêts.						
11. Met en place des instruments pour une assurance bétail.						
12. Renforce les services vétérinaires						
13. Investit sur la recherché pour les promotions de variétés de cultures adaptées aux changements climatiques.						

Lignes Directrices pour les Travaux de Groupe

1. Nommer un rapporteur pour présenter le travail du groupe
2. Identifier un animateur (modérateur) pour faciliter le travail en groupe
3. Distribuer la matrice et les critères aux membres du groupe
4. Individuellement, revoir les critères et les options, attribuer un chiffre (entre 1 et 5) dans chaque cellule d'évaluation pour toutes les options, et ajouter les chiffres et entrer le total dans la colonne appropriée.
5. Un par un, partager des scores que vous avez attribué aux options. Le rapporteur va insérer ces chiffres dans la Matrice du Groupe (Feuille Padex) et calculer la moyenne par case et par option.
6. Revoir les résultats de l'exercice et discuter en groupe, en notant là où il y a une grande disparité des résultats et essayer de comprendre le fond de ces différences. Si, après discussions, vous trouverez que le groupe veut changer le score, vous pouvez le faire
7. Notez sur le papier padex des observations sur ce processus : qu'est ce qui était difficile ? Est-ce que des échanges avec des autres ont influencé des membres du groupe ? Comment ce processus a modifié votre perception des options?

MCA RESULTS – FRENCH

	OPTIONS TO SUPPORT ADAPTATION	G1	G2	G3	Group Avg	Survey Avg Rescaled	MCA Ranking	Survey Ranking
6	Augmente la prise de conscience et les capacités des communautés pour faire face aux effets des changements climatiques et à leur capacité de la gestion des risques.	4.2	3.7	3.9	3.9	2.5	1	11
5	Renforce les systèmes d'Alerte Précoce en prévision des changements climatiques.	3.7	3.4	3.9	3.6	2.7	2	6
2	Renforcer les systèmes existants afin d'augmenter l'accès des producteurs à la diversité de semences de qualité.	3.8	3.2	3.7	3.6	2.6	3	10
7	Contribue à une meilleure intégration des systèmes de production lies à l'agriculture et l'élevage.	3.7	3.4	3.5	3.5	2.5	4	12
8	Développe l'irrigation à petite échelle	3.7	3.1	3.5	3.4	2.6	5	9
13	Investit sur la recherché pour les promotions de variétés de cultures adaptées aux changements climatiques.	3.8	2.3	4.0	3.3	2.3	6	13
1	Contribue à promouvoir le maraîchage et la production de cultures de niche, comme l'apiculture	3.7	2.9	3.4	3.3	2.7	7	7
9	Renforce la promotion de pratiques de terrain en matière de gestion efficace des eaux de ruissellement	3.3	3.3	3.4	3.3	2.8	8	5
10	Renforce le cadre juridique et institutionnel pour la gestion équitable et durable des ressources naturelles communes, telles que les plaines, les pâturages et les forêts.	3.4	3.0	3.3	3.2	3.3	10	2
4	Contribue à promouvoir des techniques pour augmenter la production de fourrage	3.7	3.0	3.0	3.2	2.9	9	4
12	Renforce les services vétérinaires	3.5	2.8	3.1	3.1	2.7	11	8
3	Clarifie les droits fonciers dans les couloirs de passage pour les animaux	3.4	2.4	2.7	2.8	3.3	12	3
11	Met en place des instruments pour une assurance bétail.	3.4	2.5	2.6	2.8	3.6	13	1


Comparaison resultats MCA et reponses ad-hoc
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Score moyen
1
2
3
4
5
6
7
8
9
10
11
12
13
Numero question
MCA_moy
Ad_hoc_moy

Groupe1

- Plus faible #9; plus fort #6; 2=>12 semences
- Différences de perceptions sur options: assurance, petite irrigation =>faisabilité
- Méthode de notation contexte d'analyse général au communautés de l'étude

Groupe2

- Options globalement partagées
- Nécessité d'une bonne compréhension de l'exercice par tous les membres du groupe
- Nécessité de pondérer certains résultats après large discussion
- Plus de détails sur les concepts utilises

Groupe3

- Privilégier les variétés a cycle court et multifonctionnelles (alimentation/fourrage)
- Un SAP OK, mais sans effet sans système d'intervention rapide
- Le faible score des actions liées à la maitrise d'eau est surprenant (#1;8;9)

ANNEX Z. NATIONAL STAKEHOLDER EVENT: EXIT SURVEY AND RESULTS

RESULTS OF THE PARTICIPANT SURVEY AND SURVEY QUESTIONS

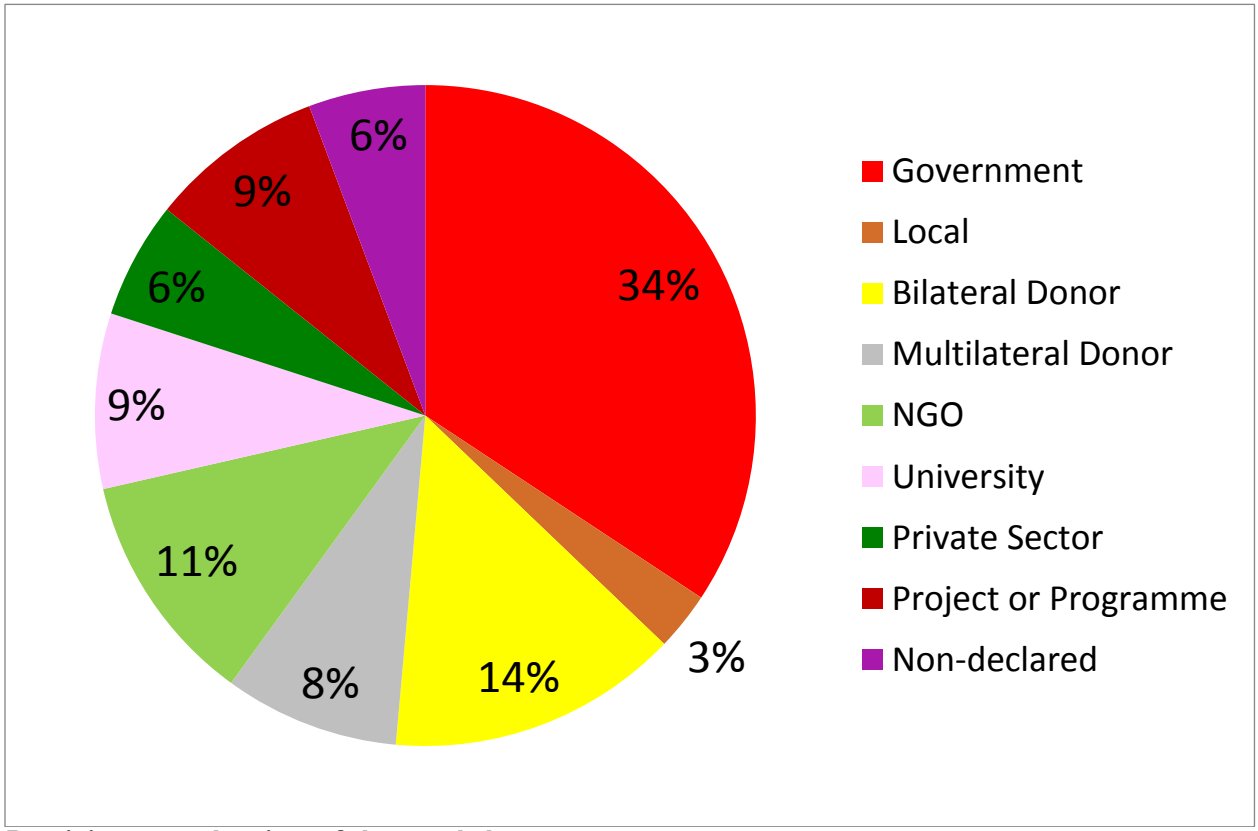
Results Presentation: Assessment of Climate Change Vulnerability in Eastern Senegal

Dakar, September 15, 2014

The results of the exit survey are as follows

Participant demographics

- Total number of participants: 41
- Survey completion: 35 people completed the survey (85%)
- Institutional distribution of the participants (see graphic)



Participant evaluation of the workshop

80% affirmed that the workshop increased his/her understanding of climate change adaptation

88% of participants affirmed that they will use the assessment their work

Requests for complementary follow-up to the presentation

- 77% requested additional workshops on one or several of the themes presented
- 74% requested translation of materials into French
- 83% requested distribution of printed copies of the reports
- 83% suggested technical field assistance

Examples of the ways participants may use this information include:

- translating materials into local languages
- diffusing information by radio and flyers
- holding workshops with colleagues
- field visits

SONDAGE DE SORTIE DES ATELIERS ANIMES PAR L'USAID SUR L'ADAPTATION AU CHANGEMENT CLIMATIQUE EN AFRIQUE DE L'OUEST

Consignes: Veuillez remplir le formulaire de sondage entièrement et le remettre à l'animateur. Toutes les réponses sont confidentielles. Merci de votre participation.

Ville et pays (entourer la réponse) **:**

a) Bamako, Mali

b) Dakar, Sénégal

c) Niamey, Niger

Nom et adresse électronique (Facultatif):

_____

Nom de l'organisation (Facultatif) :

_____

Type d'organisation (entourer la réponse):

a) Organisme gouvernemental

b) Collectivité locale

c) Partenaire technique et financier bilatéral

d) Partenaire technique et financier multilatéral

e) Organisation non-gouvernementale ou autre composante de la Société civile

f) Université ou Institut de recherche

g) Secteur privé (y compris les organisations de producteurs)

h) Société commerciale de conseil en développement

i) Projet ou Programme

Question 1 : Pour la liste d'énoncés ci-dessous, veuillez choisir le classement qui reflète le mieux votre opinion en marquant un X dans la case correspondante. Dans le cas où le thème n'a pas été abordé pendant l'atelier, veuillez marquer "sans objet" (S.O.).

Enoncé	Pas du tout d'accord	D'accord	Sans opinion	Pas d'accord	Tout à fait d'accord
Les thèmes abordés concernaient le changement climatique et l'agriculture.					
Les thèmes abordés concernaient le changement climatique et la gestion des ressources en eau.					
Les thèmes abordés concernaient le changement climatique et les conflits.					
Les thèmes abordés concernaient les prévisions climatiques et la cartographie de la vulnérabilité.					
La réunion m'a permis d'améliorer ma compréhension de l'adaptation au changement climatique.					

Y a-t-il des thèmes qui vous ont été particulièrement utiles ou sur lesquels vous auriez aimé avoir plus d'informations ? (Facultatif)

_____
_____
_____
_____

Question 2 : Pour les énoncés suivants, veuillez répondre par "oui" ou par "non".

Thèmes	Oui	Non
J'ai l'intention d'utiliser les informations présentées à l'atelier dans mon travail.		
J'ai l'intention d'utiliser les documents écrits présentés à l'atelier dans mon travail.		

Y a-t-il d'autres moyens d'utiliser les informations présentées à l'atelier dans votre travail ? (Facultatif)

_____
_____
_____
_____

Question 3 : En plus des informations présentées à l'atelier, les organisateurs souhaiteraient savoir quel suivi complémentaire vous servirait à vous et à votre organisation. Ci-dessous figure une liste de types d'actions de suivi que les organisateurs souhaiteraient considérer. Veuillez noter que les organisateurs ne sont pas certains que les actions de suivi mentionnées ci-dessous seront entreprises. Pour chaque action, inscrire un X pour indiquer le niveau d'importance relative.

Action de suivi	Très Important	Important	Plutôt important	Pas important
Organisation d'ateliers supplémentaires abordant un ou plusieurs des thèmes présentés				
Traduction des rapports mentionnés dans les présentations en français				

Action de suivi	Très Important	Important	Plutôt important	Pas important
Distribution d'exemplaires imprimés des rapports mentionnés dans les présentations				
Assistance technique sur le terrain au sujet des thèmes techniques présentés				

Veuillez fournir toute information complémentaire concernant les types d'actions de suivi qui vous seraient utile à vous et/ou à votre organisation (Facultatif).

_____

_____

_____

ANNEX AA. VALIDATION MEETING AGENDA AND GROUP PRODUCTS (FR)

VALIDATION MEETING AGENDA

ARCC Atelier de Validation

Participants:

CSE (4): Moctar Dieye, Marième Diallo, Gayane Faye, Souleymane Diop
ISRA (5) Yacine Ndour, Mbaye Diop, Katim Touré, Moussa Sall, Yacine Ngome, Malick Leye
ARCC (3) David Miller, Mamadou Baro, Sylwia Trzaska

Les dates:

Le 18 juin 19, et 20.

Lieu :

Hôtel Djollof, Dakar

Objectifs:

Identifier et valider les résultats de l'étude
Formuler des recommandations valides et uniques en fonction de ces résultats (à partager avec un plus grand public en Septembre)
Contenu du plan de présentation de l'USAID (du 19 Juin)
Contenu du plan de réunions dans le domaine (Juin 23/24/25)

Avant l'atelier, tous les participants seront familiarisés avec tous les rapports produits pour cette étude par l'ARCC, l'ISRA, et le CSE. (Le rapport final et ses annexes ont été partagés par Dropbox.)

ORDRE DU JOUR PROPOSE

Jeudi 18 Juin

Matin: ISRA et CSE Présentations

08:00 -8:30 Salutations, accueil et présentation des objectifs de l'atelier (David)

8:30-9:00 Cadre de l'étude (David)

9:00-9:45 résultats du travail de terrain (BAME)

De brefs exposés sur les résultats et les conclusions des discussions de groupes, enquêtes auprès des ménages et des entretiens avec des informateurs clés. Répondre à la question: Qu'avons-nous appris?

9:45 - 10:00 Questions de clarification

10:00-10:15 Pause-café

10:15 - 11:00 Résultats climat (Sylwia); Modélisation des cultures (Mbaye); Modélisation pastoral (Gayane).

De brefs exposés sur les résultats et les conclusions de chaque étude portant sur la question: Qu'avons-nous appris?

11:00- 11:15 Questions de clarification

11:15-11:30 Marchés (ISRA); Marchés (CSE)

De brefs exposés sur les résultats et les conclusions de chaque étude portant sur la question: Qu'avons-nous appris?

11:30-12:00 Remarques finales, résumé: qu'avons-nous appris?

12:00-1:30 Déjeuner

Après-midi: validation des résultats de l'ARCC

1:30-2:00 Le produit final: diagrammes d'araignées (David)

2:00-2:30 Exposition (Sylwia)

Présentation et discussion: L'utilisation des projections de CSE et l'ISRA pour caractériser l'exposition, et les résultats

2:30-3:00 Sensibilité (Sylwia)

Présentation et discussion: Définition, calcul, et les résultats

3:00-3:30 Capacité d'adaptation (David)

Présentation et discussion: Définition, calcul, et les résultats

3:30-4:00 Le produit final: les diagrammes d'araignées (David)

4:00-4:30 Intégration des informations qualitatives (Mamadou)

Les groupes de discussion, des entretiens avec des informateurs clés et des études de marché dans le rapport final

4:30-5:00 Discussion de l'intégration de données quantitatives et qualitatives.

5:00-5:15 Introduction à la séance de jeudi

Jeudi 19 Juin

Matin

8:30-9:15 La présentation de l'USAID (David)

9:15-9:30 Questions de clarification

9:30-10:00 Les sous-groupes (2-3)

Examen des conclusions: Chaque groupe aura un ensemble de conclusions et recommandations de la présentation. Ils vont demander: sont-ils basés dans la recherche? Doivent-ils être modifiés? Sont-ils les plus importants? Se rapportent-elles

aux changements climatiques? Les groupes peuvent suggérer des conclusions supplémentaires, de modifier ou de contester les conclusions présentées.

10h00 Pause-café

10:15-11:30 rapports et des discussions de groupe

12:00-1:00 Déjeuner

Après-midi:

01h00 Départ pour l'USAID (Moctar, Mbaye, Katim, Sylwia, Mamadou, David)

02h00 Présentation de l'USAID

Vendredi 20 Juin

Matin: Planification de le présentation aux gouvernement et bailleurs de fonds (Septembre)

8:30-9:00 Recommandations ISRA (Yacine, Malick)

9:00-9 :30 Rappel des recommandations ARCC (David)

9:30-10:00 Brainstorm: les autres donateurs - que font-t-ils à faire face au changement climatique?

10:00-10:15 Pause-café

10:15 - Discussion: (facilitée par Mamadou)

Quelles recommandations devrions-nous proposer au gouvernement? Pour d'autres bailleurs de fonds?

12:00-1:30 Déjeuner

Après-midi: La planification des réunions dans la zone d'étude

1:30 - 5:00 Planification des réunions (Mamadou)

VALIDATION MEETING GROUP RESULTS

Group 1

Agriculture

- Promouvoir des cultures adaptées (niébé, sorgho, maïs, etc.)
    - Assurer la disponibilité des intrants en quantité et qualité
    - Développer les chaines de valeur
    - Meilleure vulgarisation des itinéraires techniques
    - Rendre disponible les choix des variétés

- Intensification
    - Meilleure vulgarisation des itinéraires techniques
    - La mise à disposition des moyens de production (intrants, MO, maitrise de l'eau, financement, matériels agricoles)
    - Intégration de l'information climatique
- Promouvoir les exploitations horticoles en faveur des femmes et groupes vulnérables

Elevage

- Assurer l'accès à l'eau et aux ressources fourragères
    - Promouvoir les POAS dans certaines zones
    - Actions visant une meilleure maitrise de l'eau (forages, aménagement des mares)
    - Amélioration les zones de parcours
    - Développement des cultures fourragères
    - Promouvoir l'aviculture villageoise en faveur des femmes et groupes vulnérables
    - Intégration de l'information climatique

Marchés et chaines de valeurs

- Mettre en place des infrastructures d'accès aux marchés
- Mettre en place des systèmes d'information (climat, marchés, intrants)
- Promouvoir les plateformes orientées vers les chaines de valeur

Institutions

- Renforcement de capacités des institutions à différents niveaux sur les effets du CC
- Développer des moyens de vulgarisation de l'information climatique auprès de:
    - groupes sociaux influents (confrérie)
    - Collectivités locales
    - Population (sketch, théâtre, bandes dessinées)
    - Améliorer la flexibilité et la réactivité des institutions (interventions vers la demande, prise en compte des pratiques et savoirs endogènes)
- mettre en place des systèmes de financement adaptés aux filières d'activités
- Mettre en place des systèmes d'assurance indicielle pour l'agriculture et l'élevage

Group 2

1. Maîtrise et accessibilité à l'eau :

- Infrastructures de collectes : barrages, bassins de rétention,…

2. Gouvernance locales et Management des RN :

- Rendre plus opérationnel les OP pour la gouvernance des RN
- Système d'alerte précoce
- Mise en place et gestion de pare-feu
- Accès au crédit
- Mettre en place un système de gestion des risques.

3. Pistes et Marché :

- Accessibilité aux marchés
- Système d'information sur les prix et produits locaux

4. Accessibilité aux Intrants et matériel agricole :

- Mise en place de Coopératives pour la production de semences
- Aider à travers la Recherche à produire des variétés adaptées et beaucoup plus productives
- Accessibilité au petit matériel agricole

5. Diversification des systèmes de production :

- Gestion des parcours et couloirs de transit
- Valorisation des sous produits de l'élevage
- Promouvoir l'introduction de races améliorées
- Améliorer la santé animale
- Ensemencement des parcours et mise en place de cultures fourragères.

Consolidation Group

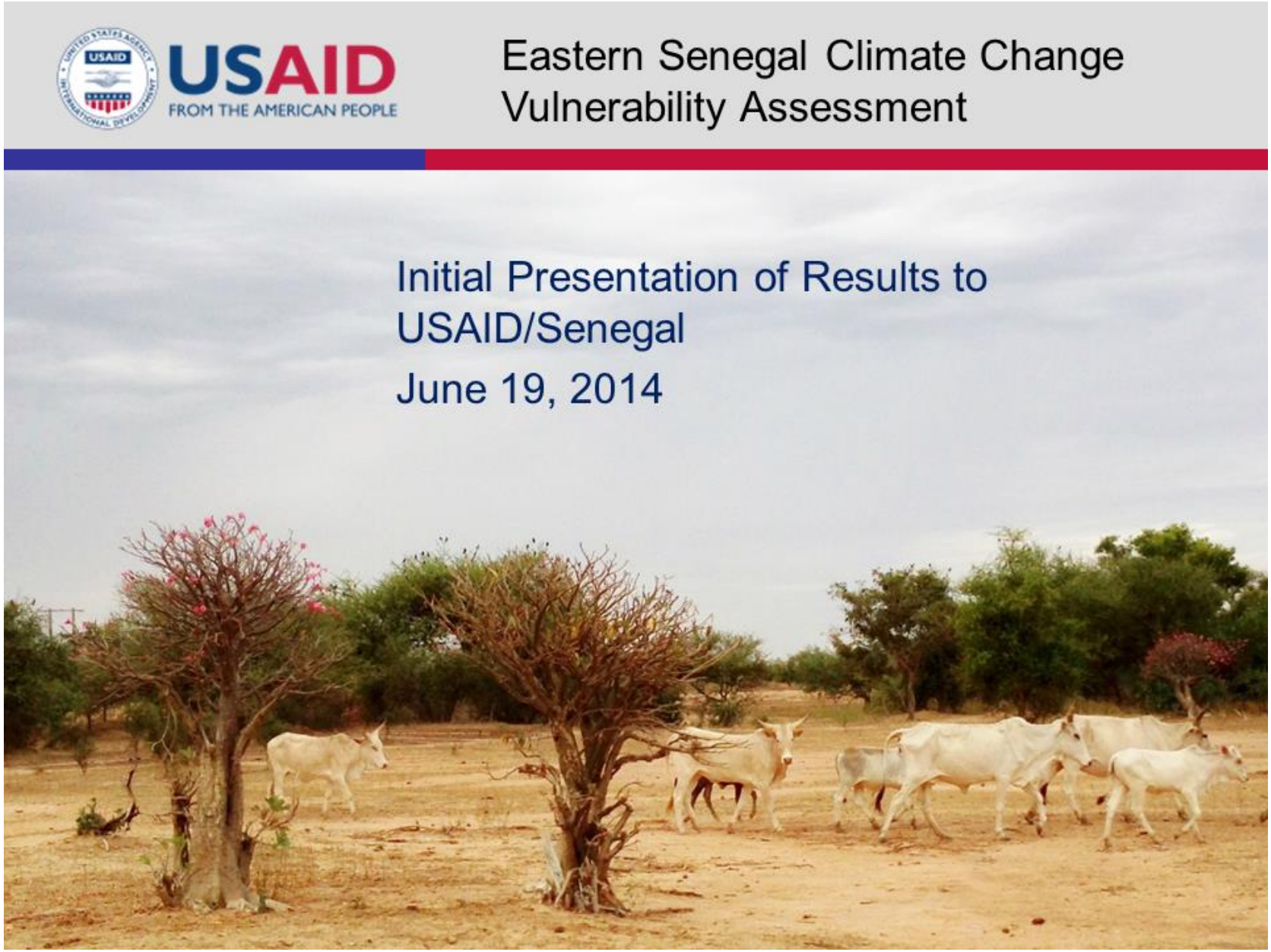
QUESTIONS TRANSVERSALES

- **GESTION DE L'EAU**
  - Rationnelle
  - Infrastructures (barrages, irrigation, basin rétention, mare)
  - Diffusion de l'information (météorologique, marchés, élevage)
- **GOUVERNANCE LOCALE**
  - Implication des populations dans la définition des grandes orientations politiques locales
  - Renforcement de capacités dans le cadre du Système d'Alerte Précoce (SAP)
  - Renforcement de capacités des comités locaux de gestion

- **AGRICULTURE**
    - Accès aux semences certifiées produits localement
    - Accès aux facteurs de productions agricole (intrants agricoles, matériel agricole, crédit adapté) et animale
    - Gestion durable des terres
    - Diversification des systèmes de production en fonction des potentialités locales

- **ELEVAGE**
    - Gestion des parcours
    - Santé animale
    - Production, collecte et conservation des fourrages

ANNEX BB. INITIAL PRESENTATION OF RESULTS TO USAID SENEGAL

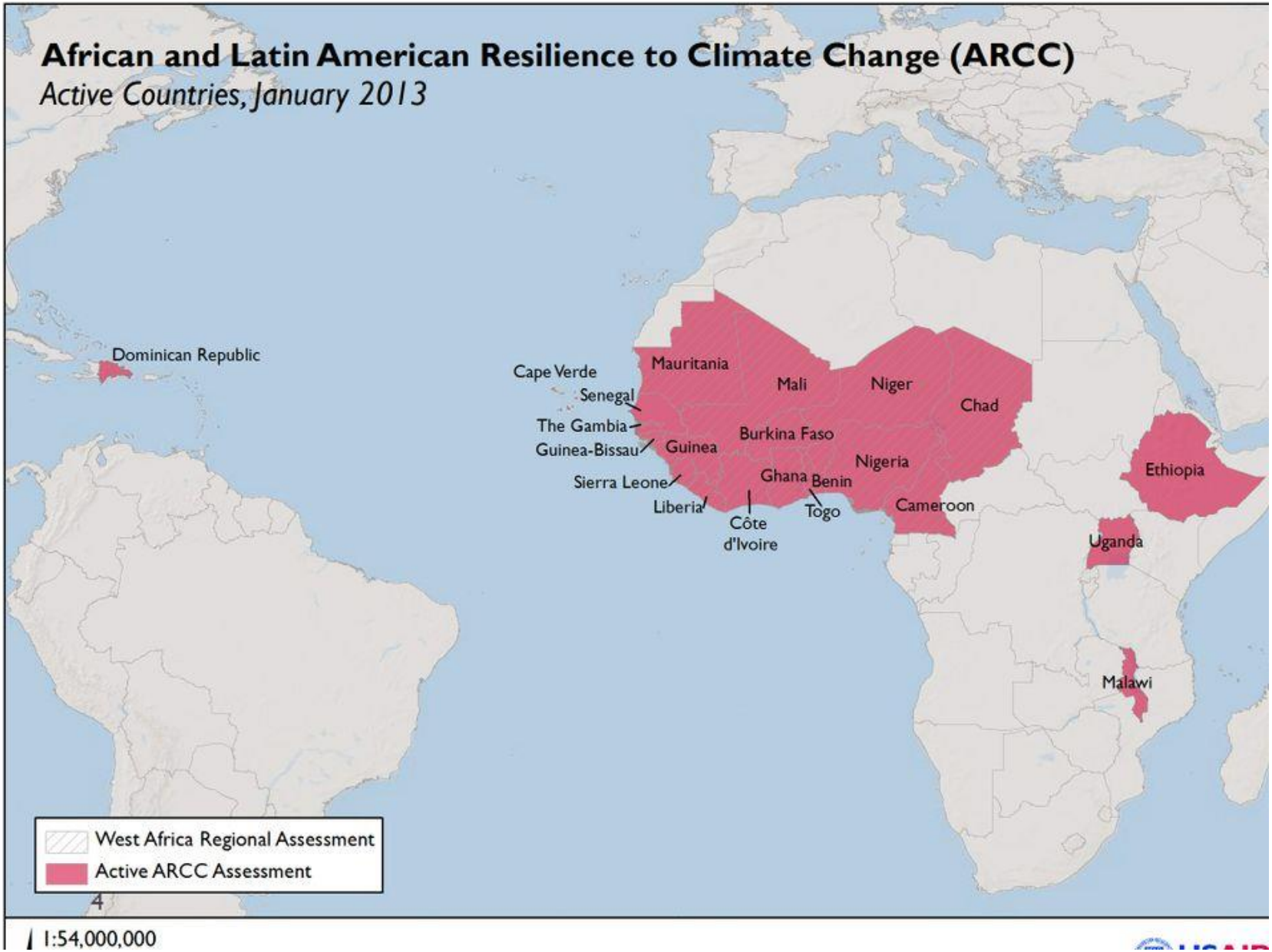

USAID
FROM THE AMERICAN PEOPLE
Eastern Senegal Climate Change
Vulnerability Assessment
Initial Presentation of Results to
USAID/Senegal
June 19, 2014

USAID FROM THE AMERICAN PEOPLE

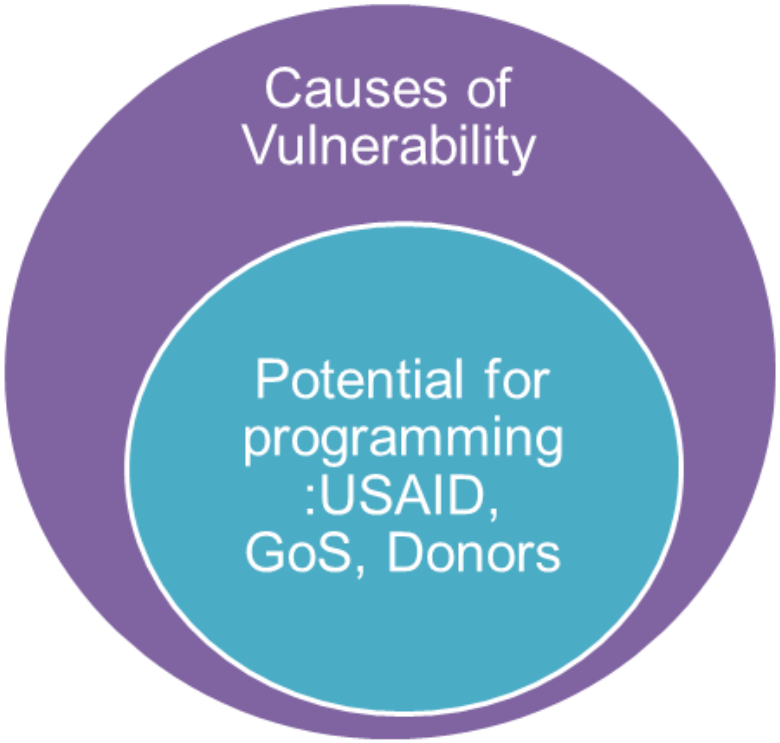
Presentation Outline

- Introduction & Research Methodology
- Selected results
- Adaptation options

Introduction & Research Methodology


African and Latin American Resilience to Climate Change (ARCC)
Active Countries, January 2013
Dominican Republic
Cape Verde
Senegal
The Gambia
Guinea-Bissau
Guinea
Sierra Leone
Liberia
Côte d'Ivoire
Mauritania
Mali
Burkina Faso
Ghana
Togo
Benin
Niger
Nigeria
Chad
Cameroon
Ethiopia
Uganda
Malawi
West Africa Regional Assessment
Active ARCC Assessment
1:54,000,000

Purpose


Causes of Vulnerability
Potential for programming :USAID, GoS, Donors

USAID FROM THE AMERICAN PEOPLE

Assessment Approach

I. Scoping

- Interviews donors and government
- Study definition with USAID/Senegal

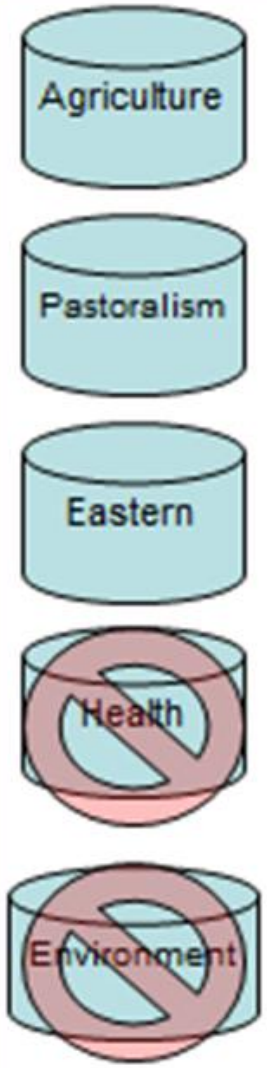
II. Data Collection & Analysis

- Vulnerabilities
- Adaptive strategies

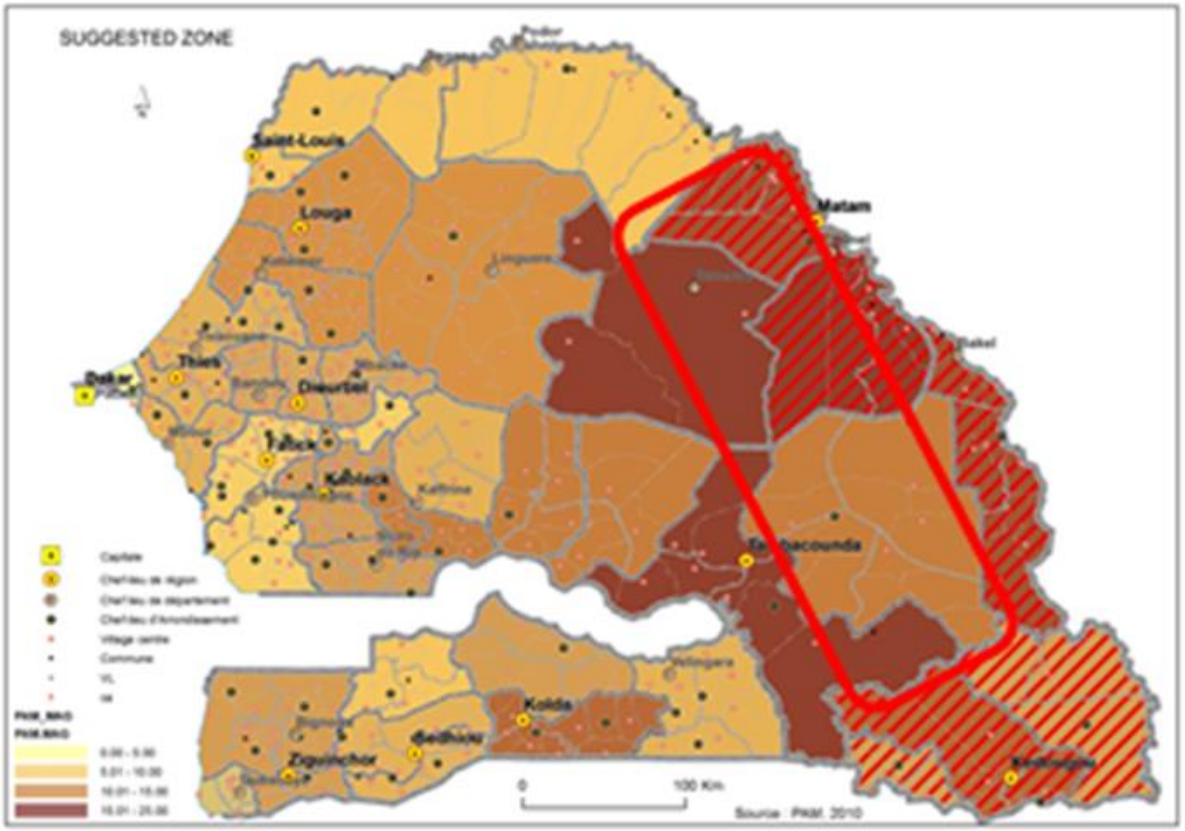
III. Validation & Options

- Findings
- Recommendations

Study area



➢ Eastern region has high malnutrition, food insecurity and USG funding rates



Hypothesis

Households with livelihoods that include livestock are less vulnerable to climate change than are households whose livelihoods primarily depend on crop agriculture.

Vulnerability Questions

1. *Which of the **three production systems** is most vulnerable to climate variability?*

2. *How will the **relative vulnerability** of households that depend on each livelihood strategy change in the **short term and in the long term**?*

3. *What **key factors** make households of the different livelihood strategies vulnerable?*

Adaptation Options Questions

1. *What **local adaptive strategies** are available and how well will they reduce vulnerability to climate change in the short term and in the long term?*

2. *What are the **institutional options** for strengthening successful local adaptation?*

3. *What are the **research and extension options** for strengthening local adaptation?*

Vulnerability Framework

Exposure	Sensitivity	Adaptive capacity
Biophysical limits imposed by climate Constraints to cropping and livestock systems produced by rainfall and temperature patterns. Largely beyond human control.	Relative dependence of households on climate-affected production systems.	Ability of a household to modify its circumstances or behavior to adjust to existing and anticipated external climate trends and shocks.

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Topics & Methods

1. Climate (Current and projected)
2. Crops & Livestock (Modeling)
3. Institutions (30 KIIs and Lit review)
4. Livelihoods (HHS -- 450)
5. Market access (Spatial analysis & Lit review)
6. Research & Extension (Lit review & Expert)
7. Historical Responses (Lit review)
8. Adaptive Practices (30 Focus Groups)

Partners

Institut Sénégalais de Recherches Agricoles (ISRA)

Le Centre de Suivi Ecologique (CSE)

Center for International Earth Science Information Network

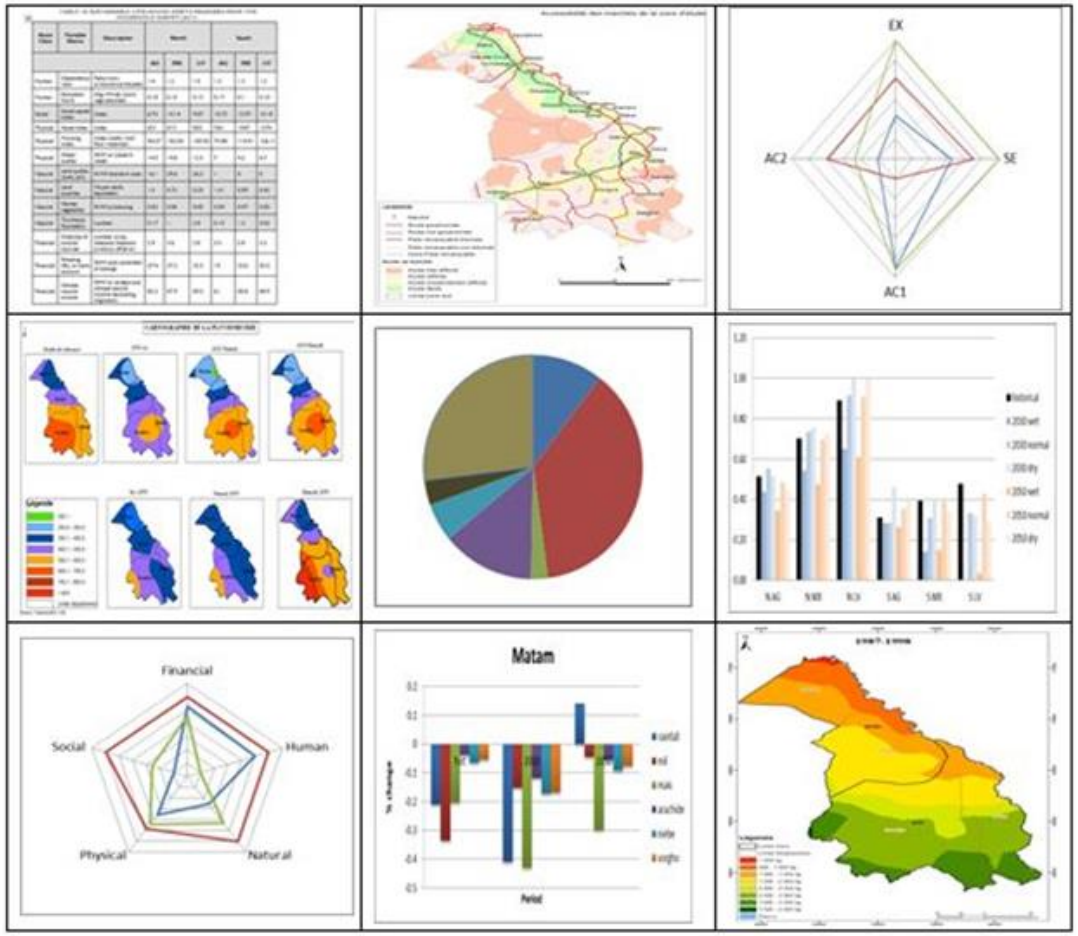
World Resources Institute

Assessment Characteristics

Mixed Methods

Collaborative

Integration & Cross-Analysis



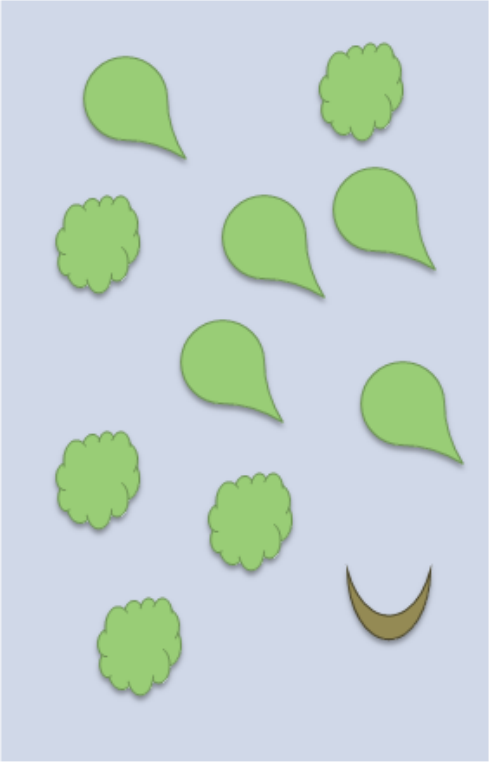
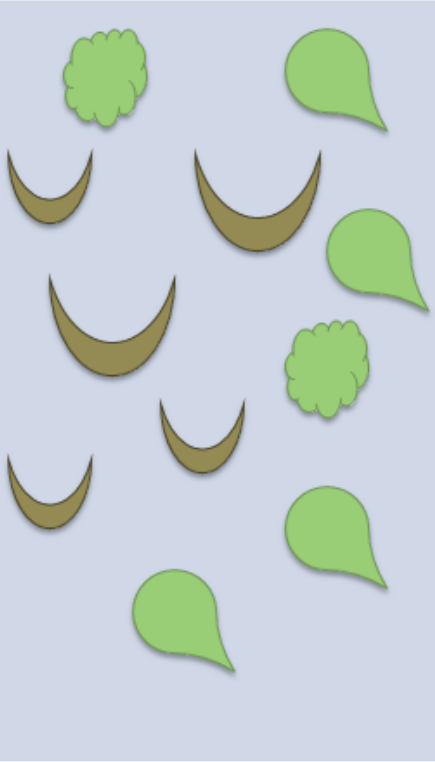
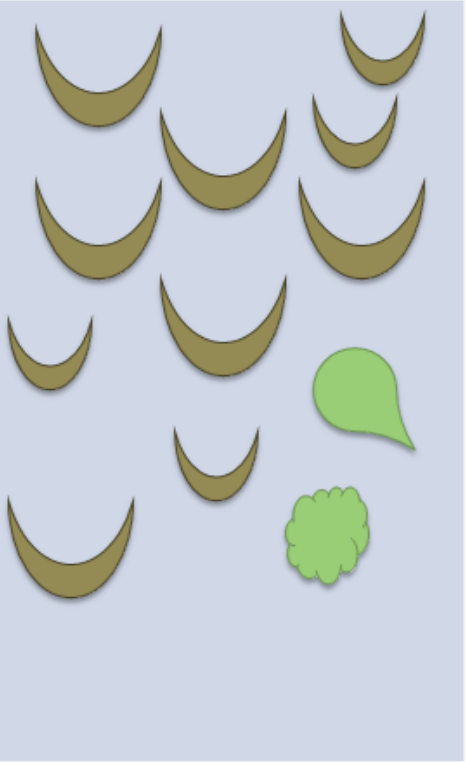
Innovative

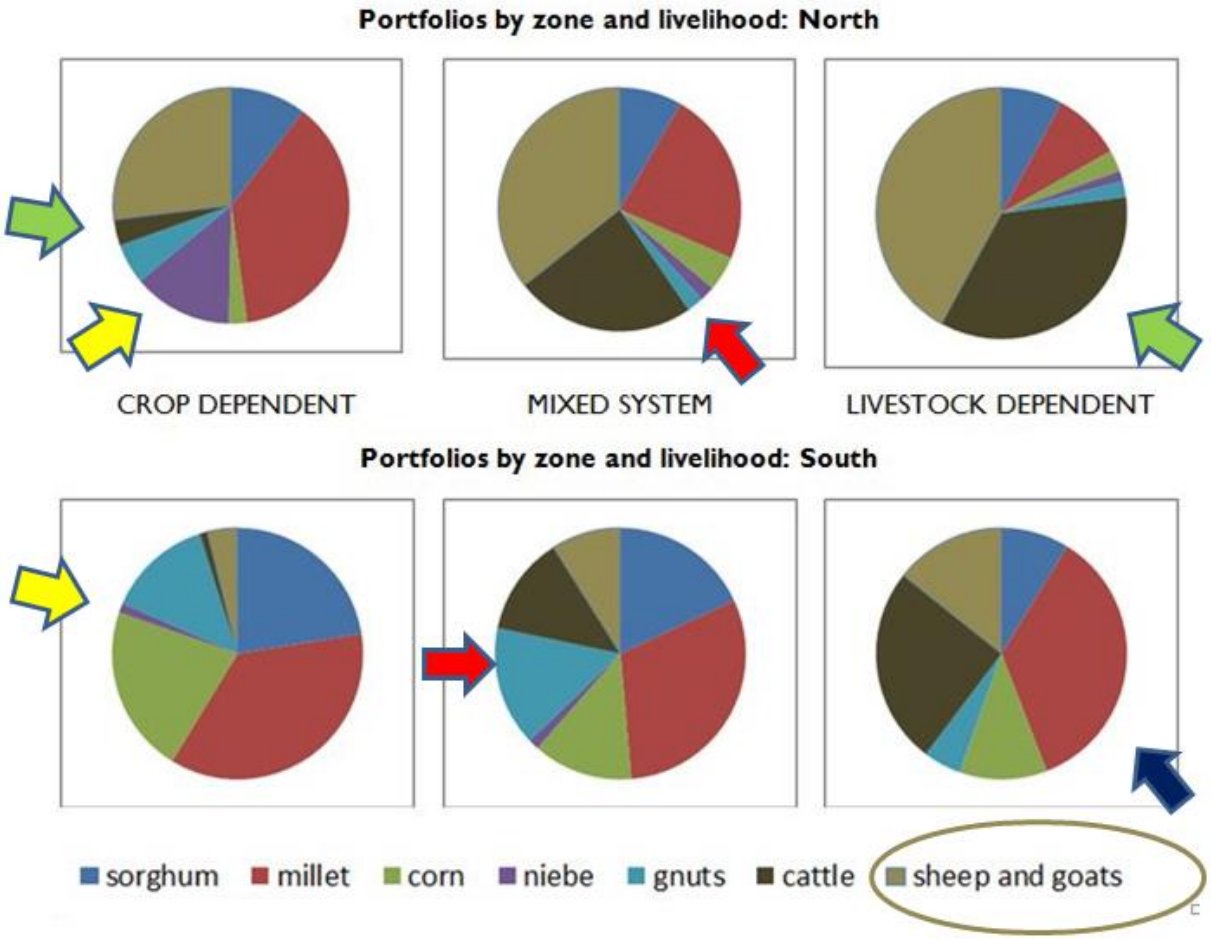
Capacity Building

Quantitative & Qualitative

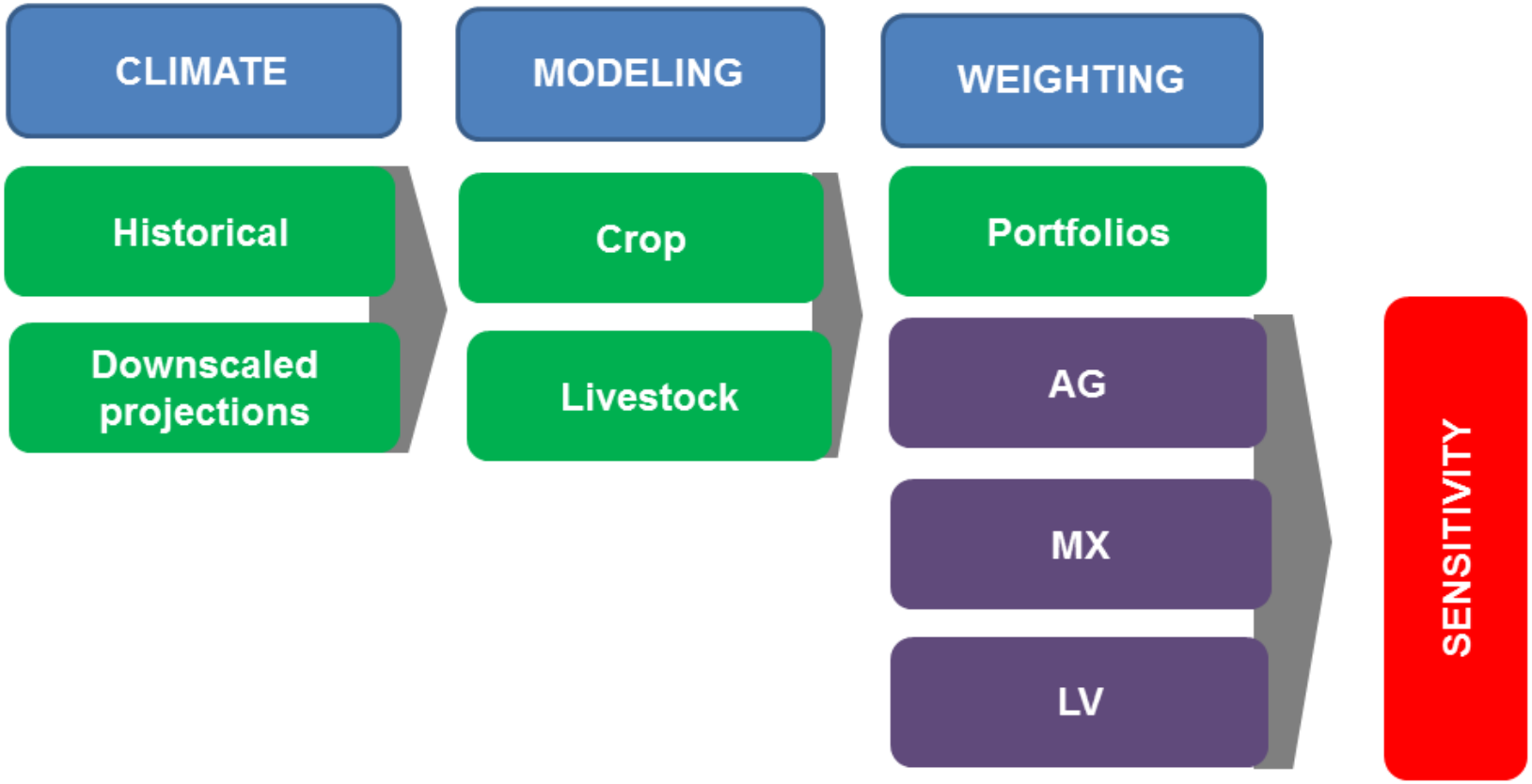
Selected results

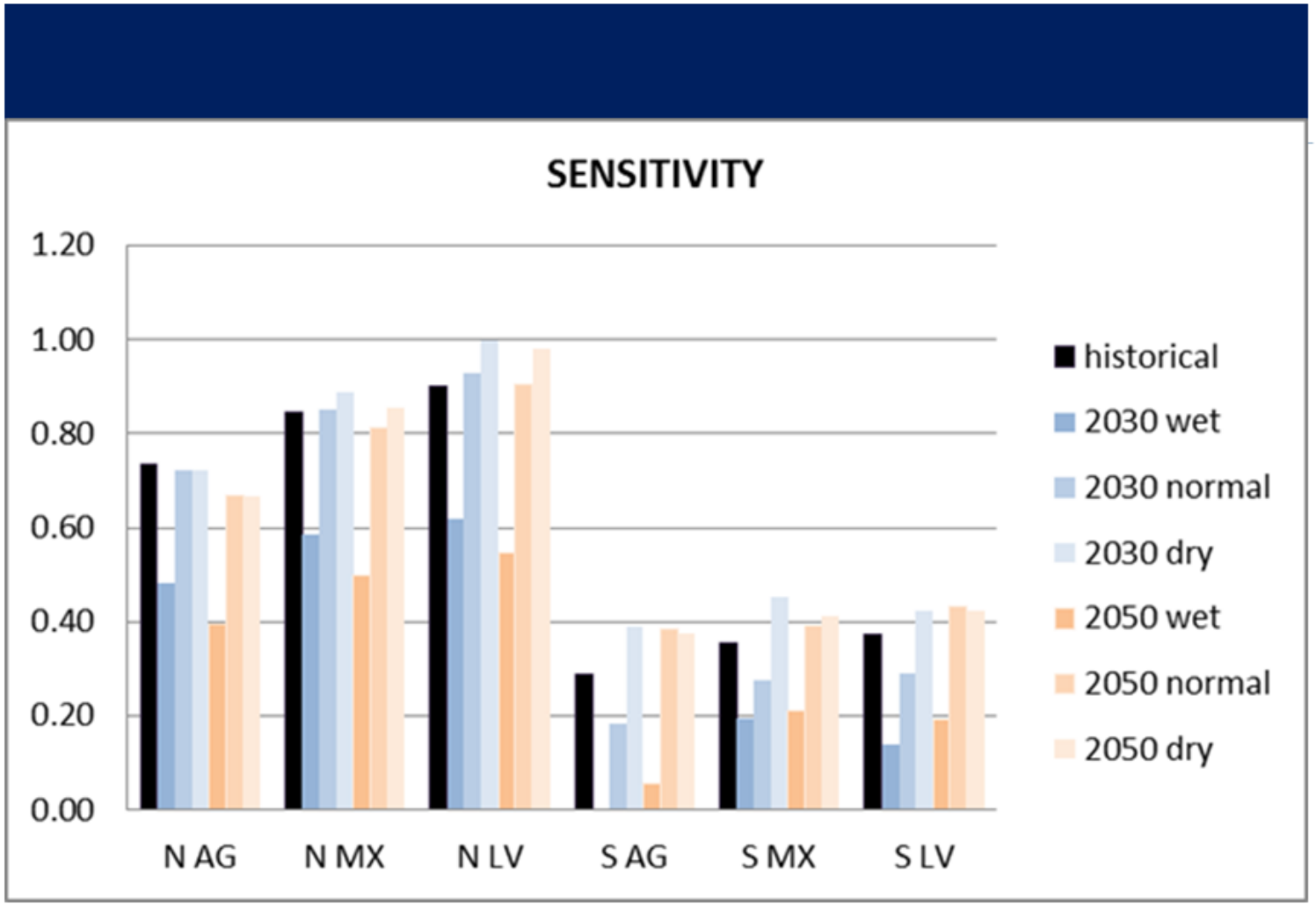
Livelihood Types

Crops (<.5 TLU/Ha)	Mixed (>.5 and <5 TLU/Ha)	Livestock (>5 TLU/Ha)
		
36.2%	39.2%	24.6%


Portfolios by zone and livelihood: North
CROP DEPENDENT
MIXED SYSTEM
LIVESTOCK DEPENDENT
Portfolios by zone and livelihood: South
sorghum
millet
corn
niebe
gnuts
cattle
sheep and goats

Impact Analysis




SENSITIVITY
1.20
1.00
0.80
0.60
0.40
0.20
0.00
N AG
N MX
N LV
S AG
S MX
S LV
historical
2030 wet
2030 normal
2030 dry
2050 wet
2050 normal
2050 dry

19

Sensitivity Conclusions

- Climate affects households more in the North than in the South
- Livestock dominant livelihoods are more sensitive in both zones
- Significant range between different model results

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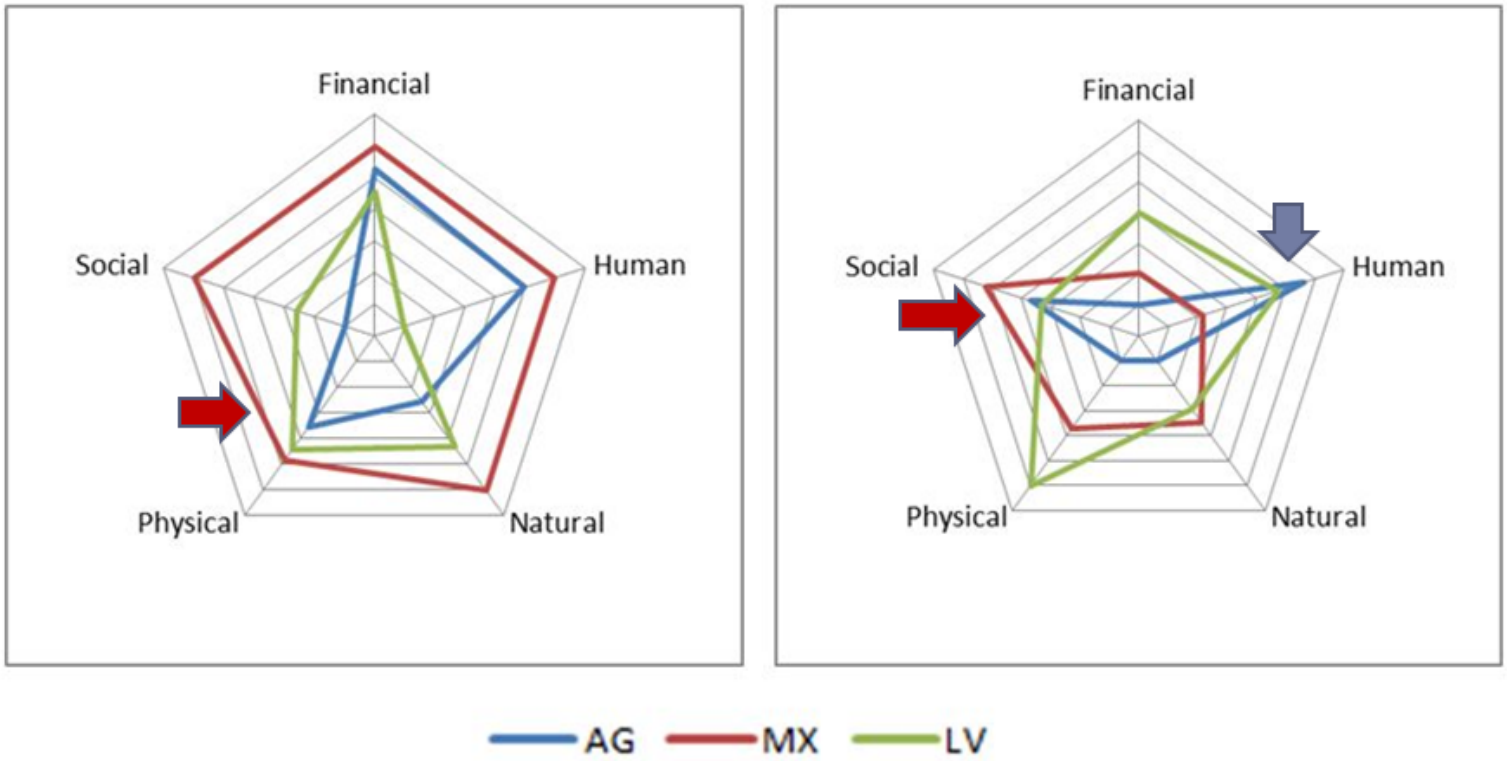
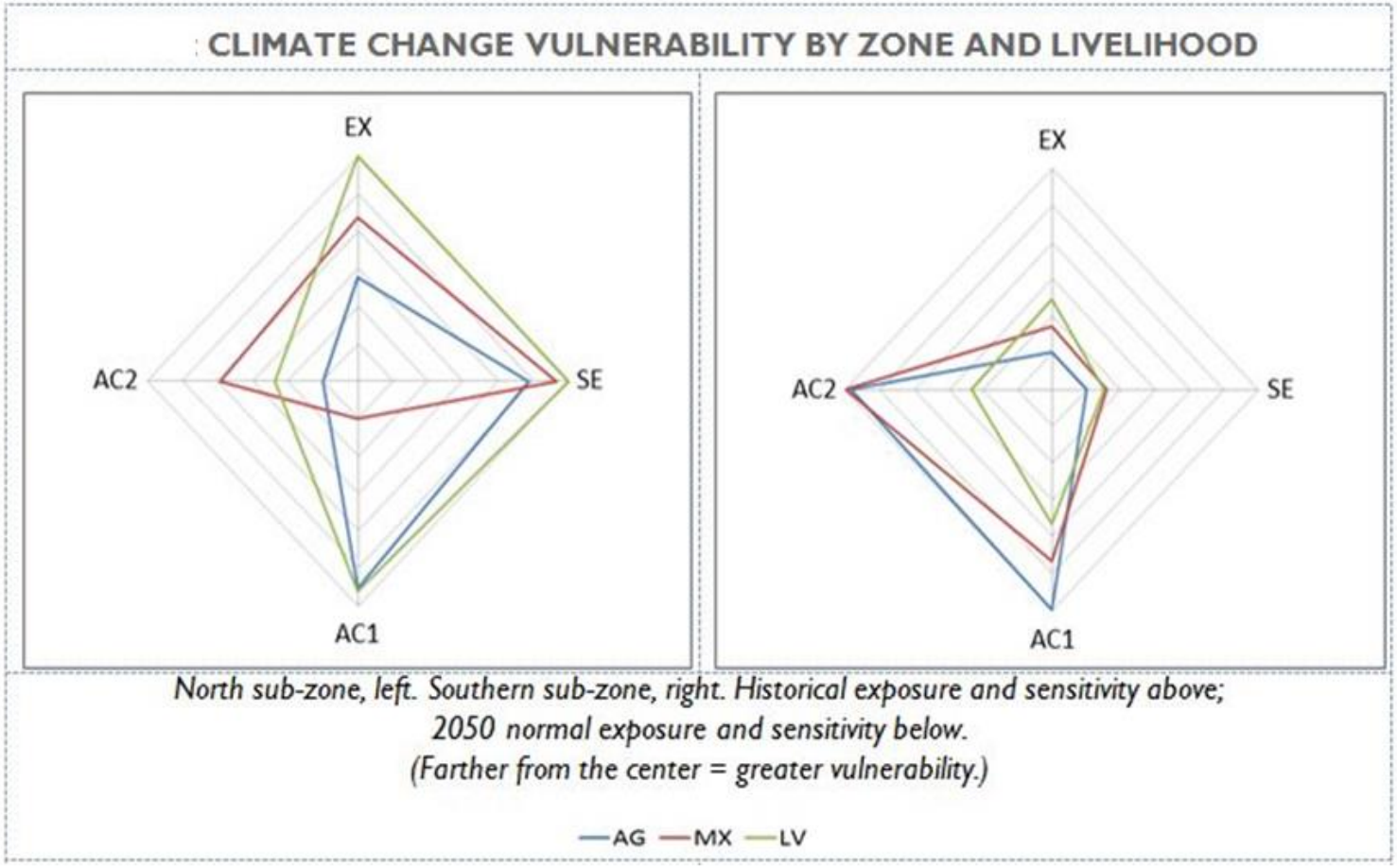
Livelihood Adaptive Capacity

Human	Dependency ratio, Education Score
Social	Social capital index
Physical	Asset Index, Housing Index, Water quality
Natural	Land quality (walo, jeri), Land quantity, vegetable gardens, TLU/Adult Equivalent
Financial	Diversity of income sources, saving mechanisms, Climate neutral income, Value crops sold/value crops produced, Value livestock sold/value herd

HOUSEHOLD ADAPTIVE CAPACITY BY ZONE AND LIVELIHOOD (AC1), NORTH (LEFT); SOUTH (RIGHT)



Study Zone Livelihood Vulnerability



Livelihood Adaptive Strategies

- Mobility
- Markets
- Storage
- Diversification
- Community Pooling
- Agricultural Innovation

Past trends expected to continue

Households will continue to diversify

- Continued investment in crop agriculture, though likely decreased investment in maize and groundnut production in the North
- Increased pressure to migrate, even if to undertake unskilled labor
- Increased investment in small ruminants

Past trends expected to continue

Increased pressure on land and pasture

- Expansion of land cultivated into marginal areas, including lowland farming and market gardens
- Increased livestock raising in the south, as well as increased transhumance south
- Increased fencing of fields in south, reduced supply of crop residue, increased demand for purchased feed
- Increased conflict over livestock pasture access

Adaptation options

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Selected Options

Beyond the Study Zone

- **Rainfall likely to return to 70-80s levels**
  - Awareness of decision makers
  - Importance of water management
- **Spatial and temporal uncertainty**
  - Robust, adaptable, solutions
    - Weather and market information
    - Crop and livestock insurance
    - Institutional responsiveness
    - Seed availability
- **Increased rainfall variability, extreme events**
  - Adapted field practices
- **Increased frequency of "bad" years for crops and livestock**
  - Pressure out of agriculture (migration/school)
  - Pressure on the south

Thank you
30

ANNEX CC. STUDY ZONE PRESENTATION PRODUCTS (FR)

MATAM MEETING RECOMMENDATIONS

Recommandations réunion Matam

A- Suggestions

- Revoir ces deux phrases qui sont contradictoires :
  - Diversité des portes feuille d'activité
  - Capacité d'adaptation est amoindrit au niveau local

B- Recommandations :

- Pour le développement des travaux communautaire
  - mettre en place des Unités Pastorales (UP) autour desquelles on met des périmètres irrigués
- Gestion des eaux
  - Aménagement de mares car les caractéristiques des sols permettent de conserver l'eau toute l'année ;
- Autres thèmes
  - Diversifier les cultures de décrue car les populations du diéri disposent souvent de terre dans le Walo cela pour palier la faiblesse des rendements des cultures pluviales ;
  - Faciliter l'accès à la terre dans le Walo aux populations du diéri qui n'ont pas, cela pour leur permettre de développer la culture fourragère ;
  - Gestion phytosanitaires des cultures de décrues ;
  - Mettre en place des spéculations à cycle court ;
  - Ne pas trop miser sur la culture de l'arachide car les conditions pluviométriques ne permettent plus ;
  - Aider à multiplier les multiplicateurs de semences ;
  - Assurer les relais entre les multiplicateurs de culture et les paysans pour faciliter à ces derniers un accès plus faciles aux semences améliorées ;
  - Améliorer et pérenniser la gestion de la santé animale qui souffre de manque de moyen ;
  - Investir sur les petits ruminants ;
  - Développer la culture fourragère ;
  - Renforcer les institutions locale de sensibilisation ;
  - Développer l'amélioration des semences ;
  - Impliquer les populations dans la gestion des parcours ;
  - Remettre à jour les parcours déjà existants ;
  - Utiliser le fourrage post-récolte produit dans le Walo ;

- Inciter le gouvernement à prendre en charge le problème de la gestion de l'eau ;
- les pouvoirs locaux à jouer le rôle de système d'alerte ;
- aider les commissions environnementales locales à faires des actions de reboisement pour amoindrir les vents et poussières ;
- les semences certifiées ne suffisent pas ;
- pour développer l'agriculture à Matam, il faire le focus sur l'irrigation ;
- étendre l'étude à la zone du fleuve ;
- le matériel lourd permettant le labour en début des saisons des pluies n'est toujours pas disponible, ce qui fait que certains paysans ratent leur campagne. Il faut donc améliorer la disponibilité de ce matériel ;
- développer les piste de production et les magasins de stockage pour améliorer l'accès aux semences améliorer des agriculteurs du Ferlo qui représente ¾ du département de Kanel. Sans cela, les agriculteurs de cette zone n'auront plus envi de prendre le risque de continuer à investir dans l'agriculture ;
- faire le diagnostic de ce qui empêche le développement des cultures fourragères ;
- développer l'assurance agricole ;
- développer le crédit agricole ;
- lutter contre les oiseaux granivores ;
- exploiter les excédents des débits des forages pour le maraichage dans le Ferlo. Cela d'autant plus que les investissements pour l'irrigation dans cette zone sont assez lourds ;
- améliorer les banques de céréales ;
- gestion des ordures ménagères ;
- renforcer gestion des ordures ménagères ;
- renforcer les comités de lutte contre les feux de brousse ;
- conscientiser les populations sur les effets des changements climatiques ;
- prendre des mesures contre la divagation des animaux ;
- aider à la gestion du pâturage ;
- améliorer l'accès à la terre pour les femmes.

BAKEL MEETING RECOMMENDATIONS (FRENCH)

Atelier Bakel

A- Constant

- Les populations locales ne se préoccupe pas trop des changements climatiques, c'est souvent une préoccupation des chercheurs uniquement
- Les animaux mettent bas un peut plus tard (augmentation de l'âge de mise bas) ;
- Récurrence des feux de brousse ces dernières années ;
- Les voleurs de bétails provoquent les feux de brousse pour pousser les animaux à pâturer plus loin afin de leur permettre de faire leur forfait plus facilement ;

B- Recommandations

- Prendre en compte les facteurs non climatiques. Exemple les oiseaux granivores qui ont augmentés ces dernières années. Ils viennent de la Mauritanie. Ce phénomène des oiseaux peut être lié à la destruction des forêts qui étaient leur refuge ;
- Prendre en compte la transhumance sud-nord à cause des fortes pluies
- Prendre en compte la disparition de certaines espèces appétées dans les parcours
- Faire un focus sur la communication et la sensibilisation ;
- Formation des agriculteurs à la fabrication de fumiers pour la restauration des sols ;
- Mettre à la disposition des agriculteurs des semences adaptées ;
- Mettre en place des systèmes de protection des pâturages (exemple pare feu) ;
- Améliorer le stockage des eaux de pluies en cherchant à réduire le ruissellement ;
- Développer l'irrigation en drainant les eaux du fleuve vers l'intérieur ;
- Faire la promotion de l'élevage intensif ;
- Favoriser l'élevage des espèces à cycle court, permettant une reproduction rapide ;
- Favoriser une démarche participative des populations ;
- Améliorer la planification foncière pour mieux gérer l'environnement et anticiper sur les changements climatiques ;
- Impliquer les populations à la gestion des forêts classées ;
- Le décret de gestion des parcours existe mais son application pose problème.il faut donc aider à son application pour une meilleure gestion des parcours ;
- L'aménagement hydraulique dans le ranch de Doli peut atténuer la transhumance vers le sud

C- Axes prioritaires :

- Disponibilité et accès à l'eau

- Sensibilisation, capacitation et gouvernance local pour une meilleure prise de conscience ;
- Système d'alerte précoce au niveau local en impliquant les populations et en les sensibilisant ;
- Evaluer le cadre juridique et institutionnel et revoir leur adaptabilité ;

D- l'avis des institutions

- Mettre en place des cadres de concertation villageoise pour mieux faire la sensibilisation ;
- Intégrer les résultats de l'étude dans la mise en place et la réactualisation des plan locaux de développement

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