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AN OVERVIEW OF

CLIMATE CHANGE AND AGRICULTURAL INFRASTRUCTURE IN UGANDA

JULY 2014

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ARCC



African and Latin American
Resilience to Climate Change Project

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Tetra Tech ARD Contacts:

Patricia Caffrey

Chief of Party

African and Latin American Resilience to Climate Change (ARCC)

Burlington, Vermont

Tel.: 802.658.3890

Patricia.Caffrey@tetratech.com

Anna Farmer

Project Manager

Burlington, Vermont

Tel.: 802.658.3890

Anna.Farmer@tetratech.com

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AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

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ACRONYMS AND ABBREVIATIONS

CRED	Centre for Research on the Epidemiology of Disasters
DSIP	Development Strategy and Investment Plan
GHG	greenhouse gas
EM-DAT	Emergency Events Database
IISD	International Institute for Sustainable Development
MDVP	Millennium Development Villages Project
MoWT	Ministry of Works and Transport
MTIC	Ministry of Trade, Industry, and Cooperatives
NRM	National Resistance Movement
UBOS	Uganda Bureau of Statistics
UCE	Uganda Commodity Exchange
UNRA	Uganda National Roads Authority
USAID	U.S. Agency for International Development
VAT	value-added tax
WRS	Warehouse Receipt Services

I.0 INTRODUCTION

Uganda's agricultural sector heavily depends on physical structures such as roads, bridges, communication networks, storage, and market places that are essential to support the production of goods and services, the distribution of finished products to market, and people's access to basic social services. Climate change has and will continue to have significant direct and indirect impacts on agricultural infrastructure in Uganda. It is predicted that Uganda will continue to experience rising temperatures, which will increase by more than 2 °C by 2030 (Caffrey et al., 2013). Additionally, the growing variability of inter-annual rainfall is projected to continue and is likely to cause an increase in rainfall during the dry season as well as an increase in the frequency of extreme events such as floods and landslides.

Infrastructure is critical to economic performance, growth, and development. Oxfam (2013) has observed that during weather-related emergencies, the damage to transport, storage, bridges, fuel supplies, and other vital agriculture-related infrastructure can be a bigger constraint on food availability and a bigger driver of food price increases than the direct impacts on food production. In developing countries like Uganda, where infrastructure is already weak, the negative impacts of projected climate change — with rising temperatures and increasing incidence of extreme events resulting in flooding, landslides, and droughts — fall disproportionately on poor smallholder farmers, whose livelihoods are already precarious as a result of numerous factors including weak markets and high transaction costs. This paper explores the extent to which Ugandan infrastructure¹ is at risk from climate change as well as the associated development implications. It also includes an overview of current initiatives and recommendations for adaptation strategies to reduce the vulnerability of Ugandan infrastructure to climate change.

¹ This analysis focuses on physical infrastructure and does not cover the "soft" infrastructure of institutions needed to promote economic development, such as legal or financial institutions, education, health care, or security.

2.0 BACKGROUND

2.1 GEOGRAPHY

Uganda is a landlocked country. Approximately 15 percent of its area is covered in lakes and rivers that power most of its national electricity grid. There are also huge tracts of papyrus and grassy swamps. The area under permanent and seasonal wetlands is estimated to cover an additional 12 percent of Uganda² – more than twice the proportion of other East African countries. Its geography poses a significant challenge to the development of infrastructure. Electrical distribution and transportation networks have to go around wetlands. Rural roads require extensive investment in culverts and drainage, and many bridges are needed. Unpaved roads, even those that do not cross wetlands, tend to get heavily mired in mud during the rainy season and heavy downpours cause temporary flooding of large low-lying areas.

IMAGE 1. TYPICAL RAINY SEASON ROAD



Source: Mugira, n.d.

2.2 TRANSPORT

2.2.1 Roads

The density of paved roads is higher in Uganda than in any of the neighboring countries. However, a combination of limited capacity and competition, poor coordination, management, and other "institutional" problems result in roads that are not built to high standards and deteriorate quickly (te Velde, 2008a).

A 2010 audit found that only 27 percent of the national bridges are regularly maintained. In fact, "Failure to maintain bridges reduces their life span and wastes the heavy investment that is used in bridge construction" (Auditor General, 2010).

The recent Uganda National Roads Authority (UNRA) strategic plan bemoans the heavy backlog of overdue maintenance required for roads and bridges (UNRA, 2014). Only 20 percent of the annual budget is applied to maintenance; the rest is

IMAGE 2. BRIDGE WASHED AWAY BY FLASH FLOOD, KASESE



Source: Kasese District Disaster Management Committee, 2013

² Of this percentage, 3.5 percent is in permanent year-round swamps, and an additional 8 percent comprises seasonal wetlands (areas of limited drainage that are dry for part of the year) and swamp forest. This analysis is based on the Langdale-Brown system of classification.

allocated to new development. Compounded by poor maintenance, badly constructed roads result in extremely high vehicle wear and tear; long and unpredictable delays; and high transaction costs that are passed on to farmers in the form of low farm-gate prices and to consumers as high retail prices.

2.2.2 Rail

At independence, Uganda inherited a railway infrastructure totaling 1,266 km. In 1990, coffee transportation was liberalized, removing the government mandate that the industry use rail transport (World Bank, 2005). Combined with low investment, poor service, and high costs, removal of that requirement set off a rapid decline of the railroads. The country now has only 321 kilometers of operational rail lines running from the Kenya border to Kampala, which still transport heavy industrial imports and produce exports on a sporadic basis. There is a high level of greenhouse gas (GHG) emissions and a high cost of transportation in Uganda as a result of the nearly complete dependence on road transport.

2.3 ELECTRICITY

In 2009, electrification covered only 9 percent of the population, leaving approximately 28 million people still without electricity (World Energy Outlook, 2011). As the result of recent construction of additional hydro-electric capacity and efforts in rural electrification, this proportion has now increased to 12 percent (Government of Uganda, 2014)³. The rest of the population relies on candles, kerosene or battery-powered lamps, generators, and fuel wood or charcoal stoves. The high costs of installation limit the adoption of solar alternatives. There are plans for significant additional expansion in power generation in the immediate future. At present, very high costs and limited access to reliable power in most parts of the country severely constrain agricultural value addition.

2.4 STORAGE AND MARKETS

Physical infrastructure for produce storage and market sales, primarily in the form of warehousing, is concentrated in a few urban and peri-urban locations in Uganda. Much of it has been constructed in the last ten years. There are only a few silo type storage facilities owned by major processors/exporters. Most storage is done at the household level using existing residential structures or traditional woven granaries. There are only seven Commercial Warehouse Receipt Services (WRS) Warehouses licensed by the Uganda Commodity Exchange (UCE) to offer cleaning, drying, and storage services for uniformly graded produce (mostly maize and beans). They issue electronic receipts that can be used as collateral for short-term bank credit. WRS supervision by the UCE has been limited and utilization levels have been low. There are now moves by the Ministry of Trade, Industry, and Cooperatives (MTIC) to institute a National Warehouse Receipts Authority that will fall under the MTIC. In recent years, the World Food Program has invested in construction of rural grain stores under farmer management, but ownership, management, and utilization levels of the warehouses remain problematic due to the weak state of the farmer organizations.

Open air markets, with minimal infrastructure, are where most farmers sell their agricultural produce and buy essential commodities and household goods. In most rural areas, these markets happen once or twice a week along major transportation routes. Traders travel the market routes with small lorries, carrying consumer goods and acting as middlemen to buy produce for larger traders and agro-

³ It is still cited as the "lowest in the world" (New Vision, 2013).

processors. Recent moves to construct permanent improved markets have had mixed results. The additional costs and added taxation create incentives for the continued operation of unregulated informal markets. Agro-processors depend on private agents who bulk produce in the rural trading centers. These agents store bagged produce in simple structures, often without adequate moisture proofing or pest control. They do not offer shelling, drying, or cleaning services. Produce is sun-dried on the ground or tarpaulins and is shelled and sorted by hand.

3.0 EXPOSURE TO CLIMATE CHANGE RISKS

Uganda lies within a relatively humid equatorial climate zone, and the topography, prevailing winds, and a significant area covered by wetlands, lakes, and rivers cause large differences in rainfall across the country. Changes in sea-surface temperatures in the Pacific, Indian and, to a lesser extent, Atlantic oceans strongly influence annual rainfall. The U.S. Agency for International Development (USAID) commissioned a recent Climate Change Vulnerability Assessment in Uganda (Caffrey et al., 2013). Key findings include the following:

- Year-to-year variations in rainfall are considerable and can exceed 30 percent of the total annual rainfall. The onset of the rains can shift by 15 to 30 days, and season duration by 20 to 40 days. Given these high inter-annual fluctuations, no significant long-term trends have been identified in rainfall characteristics (annual totals, onset, and duration of the season) for the 2030 horizon. However, a potential increase in rainfall is possible in the December-February dry season. Such an increase would have an impact on agriculture, especially with respect to tree crops (e.g., coffee) and post-harvest activities such as drying and storage. In addition, there is potential for an increase in the frequency of extreme events (e.g., heavy rainstorms) that would lead to damage through hail, flooding, landslides, and lightning strikes.
- Significant increases of approximately 0.5-1.2 °C in annual average minimum temperature and 0.6-0.9 °C in annual average maximum temperature have been observed between 1951-1980 and 1981-2010. This warming trend is projected to continue, with an increase of more than 2 °C possible by 2030. This trend will negatively affect many factors related to agriculture and livestock production as well as increase the risk of disease and pest infestations.

In the past two decades, Uganda has suffered eight major droughts affecting nearly five million people. In the same period, 18 major floods and four significant mudslides have displaced more than one million people, destroying infrastructure, disrupting markets, and cutting people off from social services (Centre for Research on the Epidemiology of Disasters [CRED] Emergency Events Database [EM-DAT], 2014). While the causes of such disasters are complex — including increases in population pressure and related agricultural practices that result in deforestation and changes in ground cover — the increase in extreme events that accompany climate change could be a contributing factor.

Kaggwa et al. (2009) estimate that weather-related disasters annually destroy 800,000 hectares of crops, resulting in economic losses of more than US\$ 120 billion (\$71 million). The annual losses from weather-related transport damage are estimated at US\$ 50 billion (\$30 million). However, such figures ignore the much greater day-to-day financial and economic losses due to electricity outages, high

IMAGE 3. FLOODS THAT RAVAGED PADER DISTRICT



Source: Daily Monitor, September 2007

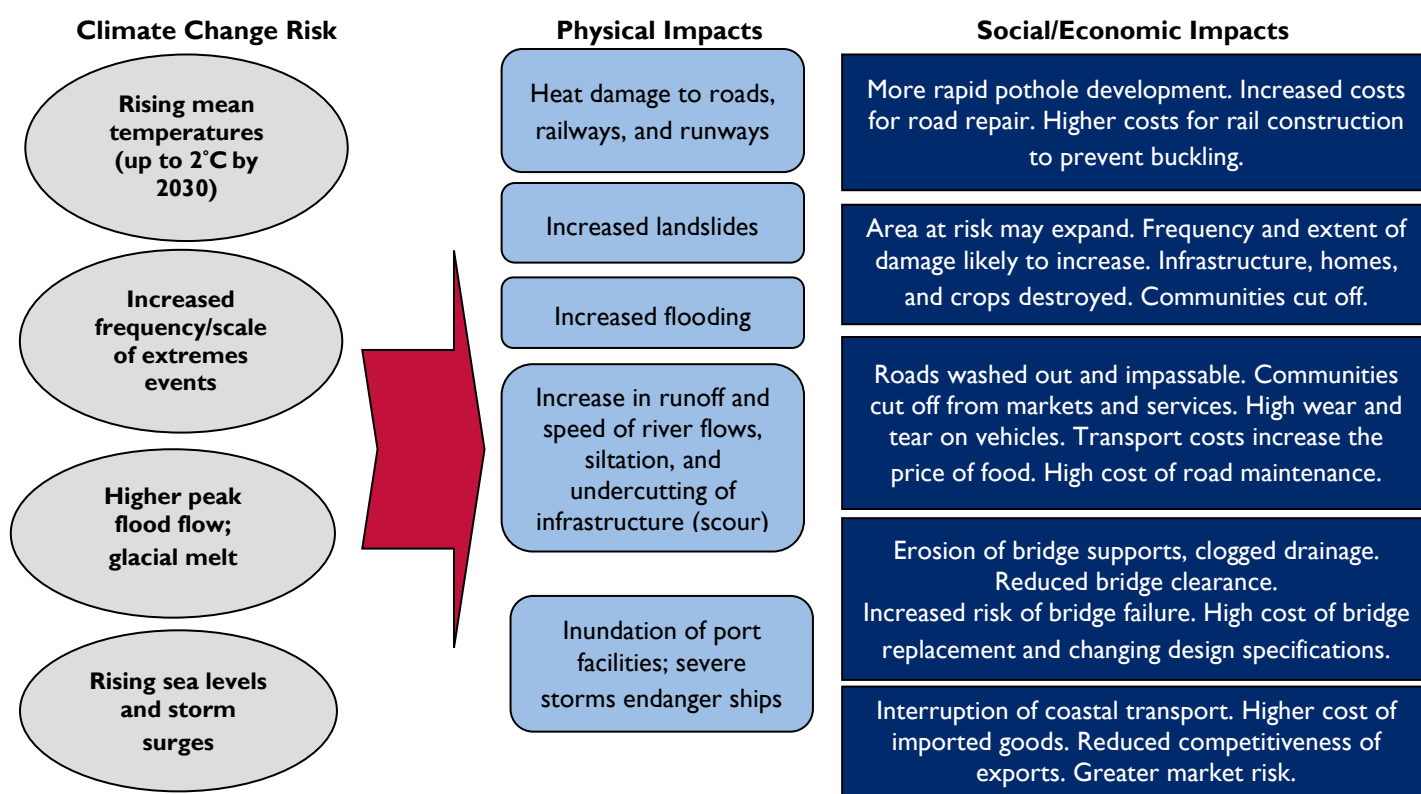
transaction costs resulting from the difficulty of reaching isolated areas in the rainy season, and extra wear and tear on vehicles.

3.1 CLIMATE CHANGE IMPLICATIONS FOR INFRASTRUCTURE

3.1.1 Transport

The impact of climate change on transportation affects all aspects of life. Investments in transportation infrastructure are substantial and designed to last decades. Climate change hazards such as flooding can destroy expensive infrastructure in hours. Relevant climate change risks include storms, flooding, heat effects, bridge scour⁴, and landslides. These risks are likely to increase in the future.

FIGURE I. CLIMATE CHANGE IMPACTS ON TRANSPORT INFRASTRUCTURE AFFECTING UGANDA



Note: As a landlocked country, Uganda does not directly experience the challenges of rising sea levels and storm surges; however, the impact on neighboring Kenya’s coast indirectly affects the cost of importing and exporting goods into Uganda since a high proportion is shipped by sea.

⁴ Bridge scour is the removal of sand and rocks around bridge abutments – one of the main causes of bridge failure (Image 5).

3.1.2 Electricity

In Uganda, weather greatly affects electricity distribution. Power outages increase in frequency during the rainy season. Poles can be blown over during heavy storms, and poorly connected wires fall, causing outages and potential electrocution. The service provided by the national grid in distant towns and rural areas is inefficient and unreliable, subject to frequent disruption, and voltage drop. Polarity reversals are not uncommon, wreaking havoc on agro-processing equipment. These problems will only increase with the predicted increases in storm intensity. Recently, falling lake levels have constrained electricity generation. Climate change is sometimes cited as a factor; however, the design of the Owen Falls extension, which increased the release of water into the Nile, is the primary cause.

4.0 SENSITIVITY TO CLIMATE CHANGE

Transport is a key component of economic development and human welfare. The poor state of Ugandan infrastructure results in high transport costs and increasing transaction costs⁵ all along the commodity value chains. As demonstrated in Figure 1, the impact of climate change is expected to further exacerbate the deterioration of transport infrastructure and increase the costs of moving people and goods from farm to market. Ugandan farm-to-market transportation costs are estimated at four to seven times those in the United States (Gollin and Rogerson, 2010). For many commodities, the cost of transportation from farm to urban market is equal to or more than the farm gate value of the product. High transport costs also make the use of purchased inputs such as improved seed, fertilizer, and veterinary supplies prohibitively expensive for many smallholders. The low use of these productivity-enhancing inputs reduces yields, keeping farmers in a vicious cycle of poverty.

IMAGE 4. PAVED ROAD WASHED OUT BY FLOOD IN KASESE



Source: UNRA, 2013

Agriculture accounts for more than 66 percent of employment, and more than 80 percent of the population resides in the rural areas. A recent study argues that the poor quality of transportation infrastructure in Uganda is one of the primary explanations for the high rural population density and the large share of labor devoted to agriculture. The study found that “high rural-to-urban transportation costs implicitly create incentives for poor people to live close to their food sources – effectively reducing the real price of food, which is their largest single expenditure category⁶” (Gollin and Rogerson, 2010). This situation is further exacerbated by the impacts of climate change on an already weak transportation infrastructure, further penalizing people who are already vulnerable in the first place.

Annexes 1 and 2 illustrate climate change related challenges for infrastructure in greater detail using commodities and locations studied intensively during the recent Climate Change Vulnerability Assessment as examples.

⁵ For specific examples of the impact of climate change on transaction costs in agricultural value chains, see Annex 2.

⁶ On average, 50% of household expenditure in Uganda is accounted for by food and drink.

5.0 CONSTRAINTS TO ADAPTATION

The Investor Survey Report 2012 quoted in the Background to the Budget 2013-14 found “insufficient energy and transport infrastructure to be the single most cited barrier to business expansion at the local level” (Uganda Ministry of Finance, Planning, and Economic Development, 2013). Infrastructure development is largely a government responsibility. Electricity generation and irrigation schemes are large-scale investments. The “national roads,” which connect districts with one another and the country with its neighbors, are the responsibility of the central government. The district and community access roads, which constitute nearly 75 percent of the roads in Uganda, fall under the responsibility of local government to construct, manage, and maintain. Local government revenue has been severely limited since the 2005 abolition of the graduated tax, which generated 60 to 70 percent of locally generated revenues (US\$ 80 billion annually).

IMAGE 5. ILLUSTRATION OF BRIDGE SCOUR UNDERMINING BRIDGE SUPPORTS.



Source: Wikipedia

A limited tax base also constrains central government revenue collection. The informal sector provides 91.5 percent of the employment in Uganda (including agriculture) and remains largely untaxed. Income tax collection falls disproportionately on the small formal sector. In 2013, direct taxation (value-added tax [VAT] and excise taxes, especially on fuel and beverages) accounted for 43.3 percent of government revenue (Uganda Bureau of Statistics [UBOS], 2013). The high fuel tax and import duties on vehicles are a pragmatic strategy to maximize revenue. Road transport is a necessity. Demand is highly inelastic (unresponsive) to price. These added costs affect the entire economy, because virtually all goods or services include a transportation element.

Other factors that currently constrain adaptive capacity include:

- **High cost and substandard quality of construction work.** Studies have documented that “firms have routinely had to accept being paid less than it takes to do the job properly. In consequence, they have often been in the position of undertaking or endorsing works done below the agreed specification or left uncompleted as resources have run out (Booth and Golooba-Mutebi, 2009). There is a prevailing sense that, due to corruption and mismanagement, government has not been delivering value for the money at its disposal, which seriously undermines the willingness of taxpayers to support the government through taxes. Corruption hurts everyone, but especially the rural producers, who are the last to experience investment and, at the same time, are those most affected by the rapid deterioration of poorly constructed infrastructure impacted by climate change.
- **Most infrastructure investment is on the national road network.** These roads are necessary but not sufficient to reduce the high cost of linking rural producers to urban markets. Emphasis on

the national network tends to bias development toward more commercial producers and large traders/processors located in towns closer to transportation. Remote areas remain highly vulnerable to the impacts of climate change on infrastructure. Increased investment in national trunk roads must be accompanied by the construction and improved maintenance of all-weather rural-feeder roads.

On the other hand, there are a number of encouraging trends:

- Since 2007, Government of Uganda **policy statements** have emphasized addressing infrastructure constraints to growth and employment generation. The National Resistance Movement "Vision 2040," which outlines the party's roadmap to development, echoes the sentiments of donors in identifying national roads and infrastructure as a binding constraint to growth. The National Roads Authority and a designated Road Fund were launched in 2008. This launch was accompanied by a large increase in the transportation sector budget. In 2010-2011 and 2011-2012, "Roads" was the third largest component of government expenditure after "General Administration" and "Defence" (UBOS, 2013). In 2012/13 and 2013/14, Works and Transportation became the highest-funded sector in the approved budget, reaching 19.2 percent of the total approved budget in 2013/14 (MFPED, 2013; MFPED, 2014).
- **Policy-level recognition of the urgency of climate proofing.** The Ministry of Agriculture, Animal Industries, and Fisheries included climate change as an important consideration in the formulation of its Development Strategy and Investment Plan in 2010. The Ministry of Works and Transport was pro-active in designing a Climate Change Adaptation Strategy in 2011. Uganda's newly passed Climate Change Policy and Costed Implementation Strategy includes transportation investment as a major component of both mitigation and adaptation. The new UNRA strategic plan for 2014/15-2018/19 makes a commitment to "incorporate climate change adaptation and mitigation considerations in the design and construction of transport infrastructure" (UNRA, 2014). The challenge, now, is to finance and implement the proposed implementation strategies.
- **Support for District infrastructure maintenance.** The Ministry of Works has concluded a large contract to supply the Districts with heavy construction equipment; the agreement includes provision for training District staff as well as equipment repair on an ongoing basis.
- **Private sector investment** in storage, access to inventory-secured credit under the Warehouse Receipt System, and value addition through agro-processing is beginning to reach a larger proportion of rural producers in some areas, and expansion of rural electrification will make this even more feasible in the future. The 2014/15 budget included funding for the creation of a Warehouse Receipts Authority under the Ministry of Trade, Industry, and Cooperatives.

6.0 RECOMMENDATIONS FOR ADDRESSING CLIMATE CHANGE EFFECTS ON AGRICULTURAL INFRASTRUCTURE

This analysis concurs with the following recommendation of a recent study of climate change adaptation in the coffee sector in Uganda: “[...] investing in climate-resilient infrastructures such as roads, irrigation systems, storage facilities and telecommunications should remain a top priority to support agro-value chain development in a changing climate” (Deckens and Bagama, 2014). It also aligns with the emphasized elements of the Uganda National Climate Change Policy and Costed Implementation Strategy, under which one-third of all adaptation investments and one-half of all mitigation investments are related to the climate proofing of national infrastructure and the development of a climate-friendly transportation sector.

The following recommendations are based on interviews with key informants, previous recommendations for policy and strategy direction, and the findings of this report.

- I. **Improve strategic planning for prevention and mitigation of the effects of climate change and non-climate change stressors on agriculture-related infrastructure in Uganda**, by building the capacity for generating and analyzing data on climate change of those institutions responsible for the construction and management of infrastructure. This recommendation includes the following elements:
 - a) Conduct a comprehensive assessment of the level of climate change vulnerability of existing infrastructure. UNRA requires additional technical assistance to undertake a climate change risk impact assessment and to make detailed technical recommendations for climate-proofing major transport infrastructure in light of expected climate change challenges.

- b) Incorporate the results of an assessment of the costs of climate change⁷ on infrastructure as well as the resulting transaction costs and detrimental impacts on access to markets and livelihoods of farmers into the 2015-2020 National Development Plan. This information will form an important input into future planning and budgetary priorities.
- c) Implement the planned activities to build the capacity of mandated institutions (Uganda Meteorological Authority, Climate Change Unit, MoWT, and UNRA) to predict and assess future climate and non-climate change impacts. This work would entail designing models for prediction and risk assessment, installing additional weather stations, and training personnel.

2. Strengthen capacity of mandated institutions to manage effects of climate change and non-climate stressors. This recommendation ensures that there are effective institutional responses to manage the effects of climate change by mandated institutions such as the UNRA, MoWT, Umeme, and district authorities. This strategy should also extend to building the capacity of staff working in non-mandated institutions, such as nongovernmental organizations and the private sector, that are involved with the construction and management of essential infrastructure. This recommendation would include the following interventions:

- a) Conduct an assessment of capacity needs and develop a capacity building programme for different stakeholders including local government.
- b) Develop emergency plans for extreme weather events (e.g., flooding, drought), focusing on improved early warning, effective contingency planning, and identification of the most vulnerable and exposed communities.
- c) Incorporate climate change mainstreaming into the Ministry of Local Government District Performance Assessment Tool, which determines the level of conditional grant funding for which districts qualify. This approach will create incentives for districts to incorporate climate-proofing of infrastructure into the district-level planning and budgeting process.

3. Strengthen community resilience. This recommendation aims at maintaining or enhancing community capacity to remain resilient to the effects of climate change.

- a) Restructure and train the local government's Disaster Management Committees to be more proactive in anticipating and preparing for weather-related disasters and in promoting climate change adaptation to reduce their impact. This work includes expanding the terms of reference of the Committees to broaden their mandate and establish climate change focal points within all affected departments. In this way, climate change can be better anticipated, and adaptation can be clearly factored into local level development planning, prioritization, and actions.

4. Reduce infrastructural vulnerability to climate change.

- a) Develop strategies to address the impact of non-climate pressures such as population growth and environmental degradation on infrastructure.

⁷ The U.K. Department for International Development funded the United Nations Environment Programme's Adapt Cost study to assess the economic costs of climate change as well as the potential costs and benefits of adaptation of key sectors in Kenya, Rwanda, Burundi, and Tanzania. These studies included a close look at transportation. A similar study recently has been commissioned for Uganda and may provide additional insights.

- b) Design and implement strategic action plans for climate-proofing infrastructure to increase its capacity to withstand severe climate change, starting with the most vulnerable.
- c) Shift to less vulnerable forms of infrastructure and those that can reduce greenhouse gas emissions while still providing cost-effective service delivery. For example, Uganda urgently needs to shift long distance movement of agricultural products for export to more efficient rail service. Uganda's "Vision 2040" foresees extensive investment in new railways linking all parts of the country with its neighbours. Strategic investment discussions are underway with a number of potential investors. In the 2013/14 budget, Uganda proposes to design, finance, construct, and operate an estimated 2,000 km of a Standard Gauge Rail on the Northern Corridor linking Mombasa to Kigali as per the agreement between the Governments of Uganda, Kenya, and Rwanda (MFPED, 2014). This investment is intended to reduce the cost of doing business in the region and make the region more economically competitive.

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ANNEX I. CLIMATE CHANGE CHALLENGES AND INFRASTRUCTURE: EXAMPLES BY LOCATION

Mbale	Luwero	Kasese	Isingiro	Gulu	Lira
<ul style="list-style-type: none"> • Mt. Elgon area has a history of landslides. Bududa has had major slides every year for the past four years caused by heavy rains following long dry spells that reduce absorptive capacity of soils. • Landslides are exacerbated by population pressure, cultivation on steep slopes, and lack of water and soil conservation measures. • Roads get cut off in the rains. Volcanic soils are very slippery. Vehicles cannot climb steep hills when roads get muddy. • Farmers have to carry produce long distances on bicycle or donkey to reach roadside. 	<ul style="list-style-type: none"> • There is a location advantage for farmers because of proximity to Kampala and to main trunk road. • This district is also better served with electricity, which facilitates market access and off-farm employment. • Farmers far from the main road face the same transport problems as in other parts of the country. • Proximity to markets makes local storage less urgent. • Luwero markets are mostly located along major roads. • Lacking market infrastructure. • Produce can reach traders and 	<ul style="list-style-type: none"> • There were major problems with landslides and flooding in 2013. • Huge boulders rolled down the mountain due to heavy rains. Five bridges were washed out; major roadways were undercut. District Headquarters were flooded. More than 4,000 people were displaced. • The District has two government irrigation schemes with lots of potential for small hydro-electric generation. Three small hydro-projects supply power to the electric mains grid started only last year. There is very limited access to the main electricity grid in highland areas. • Most of the storage facilities are located in the main town on the lowlands. There is a lack of rural storage in mountain communities. Two 	<ul style="list-style-type: none"> • Hillsides are increasingly bare. • Heavy runoff silts rivers and increases likelihood of floods. • The District lies far off the main road network running west to Rwanda. • There are no major paved roads in the entire District and a very poor access road into the district. • The main cash crop is matoke (cooking bananas). High transport costs hurt farmers. A big part of the final cost of transporting matoke to the urban markets in Kampala is consumed by transport. Farmers get less than half of the final market price. • Millennium Development Villages Project (MDVP) has been doing a lot of infrastructure 	<ul style="list-style-type: none"> • Large areas of Gulu were completely cut off in the 2007 flood. Bridges were destroyed. • Every rainy season, residents get cut off from education and health care services. • The main road to Sudan is in very bad condition due to heavy lorry traffic. • Electricity supply is very unreliable. The distribution network into the district is often disrupted for weeks at a time due to weather-related outages and poor maintenance. The polarity of the electric current is known to reverse, destroying machinery. Agro-processing is very costly. • Planned future hydro projects in northern 	<ul style="list-style-type: none"> • Large areas of Lira were completely cut off in the 2007 flood. Many bridges were destroyed. • Residents were cut off from education and health care services. • Difficulty in travel is a major reason for boarding schools. • There is significant potential for irrigation, but technical options for sustainable small-scale irrigation are not well developed. • The area has one government-constructed irrigation scheme for rice, but it has never become fully operational due to management and design problems. • Access to electricity is more stable here. The area has enjoyed

<ul style="list-style-type: none"> • This area is seriously lacking in storage and drying facilities. • Farmers dry grain along the road or on bare soil. • All subcounties have weekly markets, but they are simply open areas without any facilities or produce stores. 	<p>processors in Kampala relatively easily.</p>	<p>registered WRS warehouses in Kasese provide limited access for small farmers. They do not handle coffee.</p> <ul style="list-style-type: none"> • Coffee processing factories are located on major roads. There is only one farmer cooperative-owned warehouse and coffee huller. • Subcounties have weekly markets, but they are simply open areas without any facilities or produce stores. 	<p>development in the past five years, including rural roads repair and maintenance as well as a gravity water scheme.</p> <ul style="list-style-type: none"> • The area is benefitting from a solar rural electrification scheme in trading centers. • Computer labs in rural schools are made possible with solar power funded by MDVP. 	<p>Uganda might address this problem.</p> <ul style="list-style-type: none"> • There is one major WRS warehouse but it is greatly under-utilized. • World Food Programme heavily invested in rural storage in recent years, but farmer associations are weak after years of conflict and displacement. 	<p>significant private sector investment in agro-processing that encourages commercial agriculture and production in oilseeds.</p> <ul style="list-style-type: none"> • There is no WRS warehouse, but there is significant investment in private storage. There are weekly markets in subcounties.
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ANNEX 2. CLIMATE CHANGE CHALLENGES AND INFRASTRUCTURE: EXAMPLES BY COMMODITY

Coffee	Sweet Potatoes	Maize	Matoke	Sorghum/Rice/Beans	Cassava
<ul style="list-style-type: none"> • On-farm storage is very poor. Coffee is not currently included in the warehouse receipt system. • Processing facilities have to be located close to urban areas due to lack of electricity and access roads in rural areas. • There is a high cost of motorcycle transport to take coffee to the main road where vehicles can pass, which adds middlemen to the value chain. • Coffee quality declines when blocked roads delay transport from farm. Washed Arabica gets over-fermented, changes color, and earns a lower price; it can lose 30-50 percent of its value. Robusta gets moldy if stored or transported wet, or over-dried and breakable during hulling if too hot. • Processing costs increase due to poor quality. • Frequent power outages caused by falling lake levels and line disruption due to storms and 	<ul style="list-style-type: none"> • There is a lack of on-farm storage and technology to preserve sweet potato tubers. • The harsh dry season makes keeping planting material from one season to the next costly. • There is a high cost of transporting improved planting material long distances. • There is potential for a 20-30 percent loss of viability of planting materials if vehicles are delayed more than 24 hours on bad roads. • There is a lack of processing facilities. Sweet potatoes are consumed fresh and are bulky to transport. • The high cost of fresh-tuber transport is passed back to farmers 	<ul style="list-style-type: none"> • There are few on-farm drying, shelling, and storage facilities. The rural private sector does not offer such services. • Maize is dried on the ground and stored in the house. • Increased incidences of aflatoxin threaten human health especially when it rains during the “dry season.” • Lorries are not water proof and are often bogged down during transport. • There can be significant losses due to discoloration if maize gets wet during transport and storage. • Warehouse Receipt System not well suited to needs of small farmers due to distance, minimum quantity, and difficulty in obtaining loans. • 90 percent of commercial drying and storage capacity is near the WFP in Kampala. Maize quality is already poor by the time it reaches 	<ul style="list-style-type: none"> • There is a lack of established collection centers in rural areas, which adds many "bicycle" middlemen. • There are no refrigerated trucks, which would be very expensive. • Matoke ripens or gets damaged on the truck if it gets stuck on the road. • Poor storage and packing on lorries leads to excessive bruising and rapid loss of value. • Farmers have no power to negotiate when the transporter knows they have no alternative once matoke is harvested. • The high cost of wear and tear is passed on to consumers or back to farmers at lower prices. • There is an absence of 	<ul style="list-style-type: none"> • There is a lack of rural drying and storage facilities. • Rice and sorghum are not part of a warehouse receipt system. • Rural rice hullers exist but are of poor quality. They generally produce a high proportion of broken rice. • Distribution of rice processing capacity is limited by the electricity grid. • Diesel-operated mills are smaller and more expensive to run. • Generally, these crops are less subject to losses in transit than other crops are. • Vehicle wear and tear, high running costs, and delays all reduce profits for farmers and margins for traders. 	<ul style="list-style-type: none"> • The rural roads network is poor and largely inaccessible during the rainy season, when it is easiest to harvest cassava. • There are high costs and losses for transporting planting materials. • To produce high quality cassava flour, one must process it within 24 hours; one needs reliable transport to a factory, which greatly limits the catchment area and capacity utilization of processing facilities. • Cassava requires eight to 10 hours of sunlight for drying, so one must have transport to a factory at night. • Fresh cassava is bulky and highly perishable. One must sell it within 48 hours or turn it into

<p>floods disrupt processing.</p> <ul style="list-style-type: none"> • Poor quality reduces competitiveness of Ugandan coffee exports. • High vehicle wear and tear reduces trader and transporter profits. • Rising oceans threaten port facilities and shipping, increasing costs and reducing quality. 	<p>because of low prices during the wet season and impassable roads.</p> <ul style="list-style-type: none"> • Farmers in isolated locations cannot sell their surplus. • Transport delays mean high market losses. • There is a lack of cold storage in markets. Tubers must be sold quickly. 	<p>Kampala.</p> <ul style="list-style-type: none"> • Wet and discolored maize causes higher costs of cleaning/drying and losses to traders and processors. • Last year, the WFP rejected more than 15,000 metric tons of deliveries because they did not meet quality standards. • High distribution costs for inputs encourages fake inputs and discourages poor farmers. 	<p>cold chain facilities for urban markets and export.</p> <ul style="list-style-type: none"> • The low quality of delivered bananas limits export potential. • The lack of airfreight facilities limits competition and increases costs to exporters. 	<ul style="list-style-type: none"> • Cost of inputs increased because of transport and transaction costs. • High costs encourage counterfeiting and sale of fake inputs, especially agro-chemicals. • Low adoption of improved inputs reduces productivity and profits for farmers. 	<p>fermented flour, which decreases its value.</p> <ul style="list-style-type: none"> • Losses are passed back to farmers as low prices. • Most cassava is chipped and dried on farm; it is often contaminated from drying on the ground. It gets moldy if wet. • There is a lack of storage facilities at bulking centers.
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U.S. Agency for International Development

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524

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