



Synthesis Report: Improving the monitoring and evaluation of CIS to facilitate learning and improve outcomes



USAID Contract No: AID-OAA-A-16-00072

Cover Photo: A member of the HURDL field team interviews a woman farmer in Senegal. Credit: Tshibangu Kalala

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Suggested Citation: Carr, Edward R., Rob Goble, Sheila Onzere, and Brian Chiputwa. *Synthesis Report: Improving the monitoring and evaluation of CIS to facilitate learning and improve outcomes*. Report for the Climate Information Services Research Initiative (CISRI). Washington, DC: USAID. 54+ix pp.

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Synthesis Report: Improving the monitoring and evaluation of CIS to facilitate learning and improve outcomes

Learning Agenda for Climate Services in Sub-Saharan Africa

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Table of Contents

LIST OF FIGURES	III
LIST OF TABLES	IV
LIST OF ACRONYMS	IV
EXECUTIVE SUMMARY	V
FINDINGS: THE IMPACTS OF THE MWG	VI
LESSONS: SYNTHESIZING DISPARATE DATASETS FOR CIS MONITORING AND EVALUATION	VI
<i>Sample Stratification</i>	<i>vi</i>
<i>Identifying Uptake and Use</i>	<i>vii</i>
<i>Identifying and Measuring Impacts</i>	<i>vii</i>
<i>Confidence and Confounding Factors that could Limit our Findings</i>	<i>vii</i>
<i>The Synthesizing Process</i>	<i>vii</i>
<i>Measuring Impact by Interpreting Change</i>	<i>viii</i>
LESSONS: LIVELIHOODS ZONES AS UNITS OF ANALYSIS	VIII
<i>Outcome: Templates for Synthesis</i>	<i>ix</i>
<i>Template 1: Synthesis When There Has Been Little Coordinated Planning of Data Collection</i>	<i>ix</i>
<i>Template 2: Synthesis When There Has Been Coordinated Planning of Data Collection</i>	<i>ix</i>
<i>For Both Templates: Characterize Uncertainty to Ensure Synthesis is Rigorous and Valid</i>	<i>ix</i>
1 INTRODUCTION	1
2 SYNTHESIS REPORT GOALS	1
3 APPROACH TO SYNTHESIS	2
3.1 QUESTIONS TO GUIDE SYNTHESIS	3
3.2 DATA USED IN SYNTHESIS	4
4 FINDINGS FROM THE SYNTHESIS	5
4.1 TO WHAT EXTENT CAN WE DEMONSTRATE THAT THE TWO EFFORTS REPRESENT THE SAME POPULATION? ..	5
4.1.1 <i>ICRAF Data</i>	<i>6</i>
4.1.2 <i>HURDL data</i>	<i>7</i>
4.1.3 <i>Comparing the HURDL and ICRAF samples</i>	<i>8</i>
4.1.4 <i>Comparing non-MWG samples</i>	<i>12</i>
4.1.5 <i>Sample Comparison: Major Finding for Vulnerability Assessment and CIS Needs Identification</i> ..	<i>17</i>
4.2 WHAT ARE THE DIFFERENCES BETWEEN THOSE PARTICIPATING IN THE MWG PROGRAM AND THOSE WHO ARE NOT?	18
4.2.1 <i>Use of Improved Seed</i>	<i>18</i>
4.2.2 <i>Use of Chemical Fertilizer</i>	<i>20</i>
4.2.3 <i>Use of Manure</i>	<i>22</i>
4.2.4 <i>Animal Ownership</i>	<i>24</i>
4.2.5 <i>Asset Ownership</i>	<i>26</i>
4.2.6 <i>Crop Diversity</i>	<i>28</i>
4.3 WHAT DIFFERENCES BETWEEN THE MWG PARTICIPANT AND NON-PARTICIPANT GROUPS CAN BE ATTRIBUTED TO THE MWG, AND IN THESE CASES HOW DID THE MWG BRING ABOUT THESE DIFFERENCES?	30
4.3.1 <i>Surplus Production Livelihoods</i>	<i>32</i>
4.3.2 <i>Secure Subsistence Livelihoods</i>	<i>33</i>
4.3.3 <i>Low Resource Livelihoods</i>	<i>34</i>
4.3.4 <i>Summary: Impacts of the MWG in Zone SN10</i>	<i>35</i>

5	LESSONS ABOUT ASSESSING IMPACTS FROM THE SYNTHESIS OF THESE TWO DATASETS.....	36
5.1	SAMPLE STRATIFICATION.....	36
5.2	IDENTIFYING UPTAKE AND USE	37
5.3	IDENTIFYING AND MEASURING IMPACTS	38
5.4	CONFIDENCE AND CONFOUNDING FACTORS.....	39
5.5	LESSONS ABOUT SYNTHESIZING METHODS	41
5.6	LESSONS ABOUT MEASURING IMPACT BY TRACKING CHANGE.....	42
6	LESSONS ABOUT USING THE LIVELIHOODS ZONE AS THE SCALE OF DESIGN AND IMPACT ANALYSIS.....	43
6.1	SCALING UP TO THE LIVELIHOODS ZONE: EVIDENCE FOR VALIDITY	43
6.2	LIMITING CIS TO THE LIVELIHOODS ZONE: EVIDENCE.....	44
6.3	SUMMARY: SCALING CIS TO THE LIVELIHOODS ZONE	45
7	CONCLUSION: ELEMENTS OF A WORKING FRAMEWORK FOR SYNTHESIZING SURVEY STUDIES WITH IN-DEPTH QUALITATIVE STUDIES	46
7.1	KEY OBSERVATIONS AND FINDINGS.....	47
7.1.1	<i>Identification of vulnerability subgroups.....</i>	47
7.1.2	<i>Observation of decision-structures.....</i>	48
7.1.3	<i>Vulnerability groupings and decision-structures appear to hold across a livelihood zone.....</i>	48
7.1.4	<i>Different livelihood zones appear to have different vulnerability groupings with different decision-structures.....</i>	48
7.1.5	<i>Observing and interpreting changes over time is an unfilled gap in our synthesis.....</i>	49
7.2	A TEMPLATE FOR SYNTHESIS WHEN THERE HAS BEEN LITTLE COORDINATED PLANNING OF DATA COLLECTION	49
7.2.1	<i>Test how similar the sampled populations are in the different studies.....</i>	49
7.2.2	<i>Identify surrogate measures that substantially capture the disaggregation into vulnerability groups performed in a detailed qualitative analysis</i>	<i>49</i>
7.2.3	<i>The in-depth analysis can be used to interpret and provide explanations for differences between users and non-users of climate information services.....</i>	50
7.3	A TEMPLATE FOR SYNTHESIS WHEN THERE HAS BEEN THE OPPORTUNITY FOR COORDINATED PLANNING ...	50
7.3.1	<i>Coordination in the choice of sampling questions and in the selection of people to sample will make comparisons significantly stronger.....</i>	50
7.3.2	<i>Sequencing of studies offers further possibilities for improvement.....</i>	50
7.3.3	<i>Coverage of livelihood zones</i>	50
7.3.4	<i>Investigate possibilities for acquiring longer-term longitudinal information.....</i>	51
7.4	LIVELIHOOD ZONES APPEAR TO BE A USEFUL SCALE FOR THE DESIGN AND MONITORING AND EVALUATION OF CIS, BUT THIS NEEDS FURTHER ELABORATION AND TESTING	51
7.5	CHARACTERIZING UNCERTAINTY AND MAKING FINDINGS USEFUL FOR POLICY	51
7.5.1	<i>Fast and slow variables.....</i>	51
7.5.2	<i>Timeframe</i>	52
7.5.3	<i>Changing conditions</i>	52
7.6	SUMMARY.....	52
8	REFERENCES.....	53

List of Figures

Figure 4.1: Locator map of Livelihoods Zone 10, and the villages of Ngetou Malick and Panal.	7
Figure 4.2: Map of Senegal showing the sampled districts (circled) and presence of MWG (Adapted from Ouedraogo et al. 2018).	6
Figure 4.3: Comparison of the initial stratifications of the population into vulnerability groups by HURDL and ICRAF.	10
Figure 4.4: Comparison of the stratifications of the population after ICRAF applied a proxy of HURDL's LIG stratification to its sample.	12
Figure 4.5: Comparison of the stratifications of the population without MWG after ICRAF applied a proxy of HURDL's LIG stratification to its sample.	13
Figure 4.6: Comparison of men's reported rates of engagement in five major categories of livelihoods activity.	14
Figure 4.7: Reported rates of ownership of animals across the non-MWG components of the ICRAF and HURDL samples.	15
Figure 4.8: Rates of crop selection for three major staple crops across the non-MWG samples.	16
Figure 4.9: Reported rate of use of improved seed among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.	19
Figure 4.10: Reported rate of use of improved seed, by crop and vulnerability group, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.	20
Figure 4.11: Reported rates of chemical fertilizer use by crop among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.	21
Figure 4.12: Reported rates of chemical fertilizer use by crop by vulnerability groups, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.	22
Figure 4.13: Reported rates of manure use by crop among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.	23
Figure 4.14: Reported rates of manure use by crop, disaggregated by vulnerability group, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.	24
Figure 4.15: Reported rates of animal ownership among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.	25
Figure 4.16: Patterns of animal ownership, including tropical livestock units and draught animal ownership, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.	26
Figure 4.17: Reported rates of productive asset ownership among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.	27
Figure 4.18: Patterns of productive asset ownership across vulnerability groups, comparing those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.	28

Figure 4.19: Reported rates of crop diversity among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.....	29
Figure 4.20: Margalef index of crop diversity measure across vulnerability groups, comparing those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.....	30
Figure 7.1: The learning agenda from Carr, et al 2017, illustrating the importance of item 2.1 to the rest of the agenda	47

List of Tables

Table 4.1: Assets and agricultural production characteristic of the three vulnerability groups identified by HURDL. These were associated with specific assemblages of vulnerability, which are discussed below.	9
Table 4.2: Summary of the observed differences in agricultural practice in the ICRAF data.....	34

List of Acronyms

CIS	Climate information service
CISRI	Climate information service research initiative
CSAI	Rwanda Climate Services for Agriculture Initiative
FEWS-NET	Famine Early Warning System Network
HPIA	Household Productive Asset Index
HURDL	Humanitarian Response and Development Lab
ICRAF	World Agroforestry Centre
LIG	Livelihoods as Intimate Government approach
LRL	Low Resource Livelihoods
MWG	Multidisciplinary Working Group
PICSA	Participatory Integrated Climate Services for Agriculture
SPL	Surplus Production Livelihoods
SSL	Stable Subsistence Livelihoods
TLU	Tropical Livestock Unit

Executive Summary

The monitoring and evaluation of climate information services (CIS) presents unique challenges. Climate information has no intrinsic value, and therefore can only effect change when its users have the capacity to act on it. This capacity is shaped by a wide range of factors, including market access, local agroecology, livelihoods activities, and social structures that shape who conducts what activities and why. Most assessments of CIS identify and measure impact through broad associations between access to/use of CIS and changes in various behaviors and outcomes. While such impact assessments rigorously identify these associations, they cannot equally rigorously discriminate between the various factors that brought about the observed change, and therefore often cannot reliably select between competing explanations of observed changes.

This report seeks to improve the rigor and explanatory power of CIS monitoring and evaluation by identifying pathways of change by which individuals take up and employ the delivered information to produce an observed change in behavior or outcome, and synthesizing it with conventional large-scale survey data to rigorously explain changes associated with the implementation of CIS. Principally focused on data collected in a single livelihoods zone in Senegal, this report first describes and then synthesizes the findings of two different efforts to identify and explain the impact of a specific CIS, the Multidisciplinary Working Group (MWG) model, on farmers' behavior and outcomes. The first of these, led by the World Agroforestry Centre (ICRAF), is a large randomized survey comparing the livelihoods of those with access to and using the MWG to those without access and who do not claim to use climate information to inform their livelihoods. This work identified associations between the access to and use of climate information and changes in behavior and livelihoods outcomes. The second, led by the Humanitarian Response and Development Lab (HURDL) at Clark University, is an intensive ethnographic exploration of livelihoods decision-making in this livelihoods zone that identified likely pathways through which weather and climate information might inform the livelihoods decisions of different residents of the zone. Each of these efforts has been described in separate, detailed reports (accessible at https://www.climatelinks.org/resources/field_resource_projects/Learning%20Agenda%20for%20Climate%20Services%20in%20Sub-Saharan%20Africa-274). In this report, we synthesize these two efforts, using ethnographic data to rigorously interpret survey findings and rigorously identify specific impacts of the CIS on the behavior of specific users. Further, we used this pilot as an opportunity to identify the challenges such synthesis presents and suggest means of managing these challenges to enable similar syntheses for other CIS.

The synthesis of two very different types of studies achieved results that could not have been obtained in a single type of study. **An important finding from the synthesis was clear evidence of behavioral change: access to and use of the MWG model is causing people to make different decisions.** We also drew a number of useful lessons from the synthesis work about the evaluation process and about the synthesis process itself. These included lessons about (i) the need for care and in-depth study to make meaningful stratifications of data sets on users and their needs, (ii) appropriate measures of uptake and use, (iii) measuring impacts and interpreting change, (iv) characterizing confidence in and limits on findings, and (v) the synthesis process itself. Another important lesson concerns the scalability of findings: this work provides early evidence that FEWSNET livelihood zones provide a plausible spatial scale for generalization. Finally, we have used our experience in this study to suggest a template for future synthetic work.

Findings: The Impacts of the MWG

Senegal's MWG model, first piloted in 2011, is a CIS which translates weather and climate information into actionable information for farmers at the national and local levels to achieve three main objectives: (i) help farmers to master their farming calendar, (ii) assist farmers in choosing dates for cropping operations, and (iii) secure people and property. The MWG provides four broad types of weather and climate information: seasonal forecasts; 10-day forecasts; daily forecasts; and instant forecasts for extreme events. At the national level, the MWG is composed of representatives of the Department of Agriculture (DA), the Institute of Agricultural Research of Senegal (ISRA), the Ecological Monitoring Center (CSE), the National Agricultural and Rural Council Agency (ANCAR), the National Agricultural Insurance Company of Senegal (CNAAS), and the National Agency of Civil Aviation and Meteorology (ANACIM). This group produces climate information, interprets it into actionable decisions, and communicates these products to users at the local level. At the local scale, MWGs consist of Senegal's decentralized technical services, farmers and local farmer organizations, local administrative authorities, NGOs, and the media. Local MWGs are responsible for collecting climate information from ANACIM, disseminating that information to farmers, monitoring harvests and potential agricultural shocks and stressors, and managing early warning systems that use the climate information produced by ANACIM.

The synthesis of ICRAF's and HURDL's data suggests the following impacts of the MWG:

- 1) **Though it is a new program, the MWG is already impacting user decision-making.** There is evidence for the impact of the MWG on a variety of livelihoods decisions, crossing all parts of the agriculturalist population of the livelihoods zone examined for this project.
- 2) Access to and use of the MWG informs and appears to encourage farmer efforts to invest in critical agricultural inputs such as improved seeds and chemical fertilizer. This pattern was most pronounced for the use of chemical fertilizer. The pattern was less pronounced in improved seed, which may reflect either the presence of local varieties well-suited to existing environmental conditions, the reliability of different aspects of the CIS (for example, where short-term weather forecasts are very reliable even if seasonal forecasts are not), or local preferences related to taste or other crop characteristics which shape seed selection.
- 3) **CIS impacts are produced through sustained efforts.** The impact of the MWG on the overall material situations of its users is not immediate. Despite the observed changes in decisions and investment described above, those with access to and using the MWG did not have higher levels of draught animal or productive assets than those without access and not using the information. However, this is a very new program, and most of those using it have only done so for a few seasons. Durable impacts on the asset situations of users may take several more seasons to become apparent. This suggests that in this zone farmers incorporate climate information into their decision-making through pathways that start with agricultural production, which then yields income that can be invested in durable assets.

Lessons: Synthesizing Disparate Datasets for CIS Monitoring and Evaluation

Sample Stratification

1. In the context of M&E, the impacts of CIS will be uneven across a population, and therefore aggregate measures of uptake, use, and impact will obscure critical differences in the drivers of these outcomes that make the adjustment of existing programs, and the effective learning from completed programs, difficult.

2. Meaningful stratification represents the situations of different users of CIS and their needs. In nearly all cases, the stratification of the population should pay attention to the social characteristics that shape the roles and responsibilities of individuals vis a vis activities that might be shaped by climate information.
3. Achieving meaningful stratification requires empirical evidence for the distribution of vulnerability and resilience in the population and for break points where decisions about the use of CIS might change. There is no reason to assume that vulnerability (or resilience) are normally distributed in an agrarian population.
4. A detailed, qualitative vulnerability assessment can provide the data needed to meaningfully stratify a representative set of users in a larger quantitative dataset. Using such a vulnerability assessment, one can construct proxies in terms of things measured in the larger dataset, such as asset ownership. Such proxies can produce empirically informed stratifications for much larger populations.

Identifying Uptake and Use

1. Many CIS projects assume that success is demonstrated through very high rates of information awareness, uptake, and use. However, most climate information is useful for only a subset of a given population, and therefore the reporting of high rates of uptake across an entire population are likely misrepresentations of impact.
2. The uptake of CIS should not be gauged against 100% of the population, but that proportion of the population with the authority and ability to use weather and climate information.

Identifying and Measuring Impacts

1. Most CIS have relatively narrow pathways through which they can catalyze change in people's livelihoods.
2. The impacts of a CIS, and the different information it provides, are often highly differentiated within a given population of users. Measures of impact that aggregate these different users can overgeneralize impacts, while overlooking specific impacts important to particular users.

Confidence and Confounding Factors that could Limit our Findings

1. Livelihoods decision-making structures are, under normal conditions, slow to change. Therefore, decision-making is likely to endure across a project cycle. We expect, however, that in the context of catastrophic change or events, even durable decision-making structures could undergo rapid change; these were not circumstances that we observed in this project.
2. Specific outcomes of these decisions will vary with the economy, weather, and other factors that can change season by season, or even within a season, producing potentially large differences in outcome from the same activities and the use of the same CIS.
3. Evaluating a CIS across seasons could capture the different outcomes of these CIS-informed decisions, and any changes to the decision structure that might result from those outcomes.

The Synthesizing Process

1. Assessing the impact of an intervention such as a CIS requires quantitative measurements of change generalizable to a population and qualitative explanations of the pathways by which that change came about. Both types of studies are germane and synthesizing them is necessary. However, such synthesis can be sequenced. For example, one might use qualitative/ethnographic work to establish initial interpretive frameworks. Such frameworks might then

inform the interpretation of data from ongoing survey collection that seeks to identify patterns of change associated with the CIS.

2. The nature of the synthesis needed is determined by the questions at hand. This, in turn, can shape the specific character of implementation for different methods under this synthesis. There is no a priori starting point for a synthesis of methods aimed at identifying the impact of a CIS. Instead, the starting point is the impact one expects to measure, and the character of the CIS whose impact is being measured.
3. Coordinating methods can benefit overall data collection. The nature of this coordination and planning depends on the information one needs to collect.
4. The greater the degree of coordination between different data collection methods, the more comprehensive the possible synthesis.

Measuring Impact by Interpreting Change

1. Changes in material circumstances and outcomes can be driven by a wide range of factors, from the use of climate information to shifts in market or environmental conditions. As a result, these circumstances can change quickly, and be difficult to rigorously attribute to an intervention
2. Livelihoods decision-making tend to be durable, barring catastrophic shocks that can completely destabilize livelihoods and their attendant social structures. As a result, it is reasonable, under conditions outside of a major shock, to expect that understandings of such decision-making will hold for at least five years, and possibly much longer.
3. It is possible to verify the ongoing validity of initial understandings of livelihoods decision-making through much less intensive targeted investigations. For example, repeated surveys aimed at the different decisions and outcomes can identify when either decisions or outcomes appear to change, triggering targeted ethnographic investigations into those changes to explain their sources and importance vis a vis the CIS.

Lessons: Livelihoods Zones as Units of Analysis

A central question for CIS in development is the number of people who can be served by a single service. Because effective CIS address clearly defined users and very specific needs, it is impossible to design a single CIS that addresses the needs of each household or community in a given country. The design of effective CIS requires understanding the extent to which understandings of users and needs scale up.

1. The evidence in this report strongly suggests that the livelihoods zone is the optimal scale for the design of a CIS.
2. Within a livelihoods zone, the decision-making structures, available activities, available resources, and local environment are similar enough to allow for the reliable identification of users and needs, and the meaningful measurement of CIS impact.
3. Scaling beyond a livelihoods zone invokes new users, decision-making, resources, and environments such that the original CIS and the information it delivers are unlikely to meet the same specific needs of the same users in the new livelihoods zone.
4. Just as CIS design needs to adapt to specific livelihoods zones, so too does CIS evaluation. The rigorous attribution of observed changes in livelihoods and well-being to a CIS in one zone is unlikely to apply to those seen in another zone, and therefore the most meaningful evaluation of CIS will be livelihoods zone-specific.

Outcome: Templates for Synthesis

The synthesis effort in this report suggests tentative templates to guide future synthesis efforts for CIS M&E. One template applies when the data to be synthesized is gathered through uncoordinated efforts, or the product of limited coordination. The other applies to situations where data collection can be coordinated at the planning stage. Regardless of which template applies to the situation at hand, a third template guides efforts to characterize the uncertainty that emerges from these synthesis efforts.

Template 1: Synthesis When There Has Been Little Coordinated Planning of Data Collection

1. Test how similar the sampled populations are in the different studies.
2. Identify surrogate measures that substantially capture the disaggregation into vulnerability groups performed in a detailed qualitative analysis.
3. The in-depth qualitative analysis can be used to interpret and provide explanations for observed differences between users and non-users of climate information services in larger randomized quantitative datasets.

Template 2: Synthesis When There Has Been Coordinated Planning of Data Collection

1. Coordinate the choice of sampling questions and the selection of people to sample, as this will make comparisons significantly stronger.
2. Sequence studies to allow qualitative data to inform the design of quantitative data collection and the interpretation of quantitative data sets.
3. Ensure coverage of livelihood zones includes a range and variety of individuals
4. Investigate possibilities for acquiring longer-term longitudinal information to track impact over time.

For Both Templates: Characterize Uncertainty to Ensure Synthesis is Rigorous and Valid

1. Identify variables that can change quickly versus those that will change more slowly. Slow variables, such as livelihoods decision-making structures, can help interpret changes in fast variables, like crop selection.
2. Identify the ways in which the timeframe of data collection might introduce uncertainty into the synthesis. For example, was the data collected in different years, under different market and environmental conditions that might influence measured outcomes in the data collection efforts?
3. Identify how changes in conditions might impact fast and slow variables. Slow variables tend to endure except in conditions of catastrophic change, and therefore any assumptions about the stability and continuity of such variables must be supported by evidence that there have not been such changes.

1 Introduction

The Humanitarian Response and Development Lab (HURDL) at Clark University and the World Agroforestry Centre (ICRAF), working under the Climate Information Services Research Initiative (CISRI), conducted parallel assessments of the impacts of two Climate Information Services (CIS). The first was the Rwanda Climate Services for Agriculture Initiative (CSAI), particularly the Participatory Integrated Climate Services for Agriculture (PICSA) program used to circulate climate information and advisories. This assessment focused on two livelihoods zones in Rwanda in which CSAI was active. The second was the Multidisciplinary Working Group (MWG) model in Senegal. The work in Senegal focused on multiple communities in the same livelihoods zone. These parallel projects (Coulibaly, Nakelse, and Dongmezo 2018; Chiputwa et al. 2018; Carr et al. 2019; Onzere et al. 2019) sought to test existing good practice in the evaluation of CIS, and experiment with new assessment tools to better understand their value for CIS assessment. This report, which focuses principally on the evaluation of the MWG model in Senegal, with some supporting evidence from the CSAI evaluation in Rwanda, we synthesize the findings of these parallel efforts to better understand what we can learn from these different efforts, and what the synthesis of the data and analysis from these efforts contributes to both CIS evaluation and our understanding of CIS impacts.

2 Synthesis Report Goals

A fundamental challenge in the evaluation of any project is the identification of impacts and the rigorous explanation of the causes of those impacts. Much evaluation work identifies associations between observed changes in some form of outcome and a particular intervention. Such work identifies a relationship between an intervention and an outcome, without illuminating the pathways by which that intervention produced the observed changes. For example, a rigorous randomized control trial (RCT) might demonstrate that farmers receiving information about the seasonal onset of rains produced harvests 10% larger than those of farmers who did not receive this information. However, this does not explain *how* the onset information was translated into this impact. As a result, explanations of rigorously-observed patterns often face challenges because there is no universal pathway by which information produces changes in agricultural outcomes (see Figure 1 in Carr 2014 for an illustration of this complexity). Did this information prompt farmers to plant different crops, different varieties, adopt different practices, or something else altogether? Did all farmers get to this outcome in the same way? Is this outcome replicable, or does a 10% increase in yield produce outcomes (such as the economic empowerment of women, which in some contexts can threaten men's status) that might later disable the pathways through which this impact was realized for some farmers? While identifying associations between interventions and outcomes is critical to the evaluation of CIS and other development interventions, these specific pathways, which often cannot be identified without deep understanding of the context, are what development donors and implementers need to understand if they are to learn from such evaluation and design appropriate interventions in the future. Without these pathways, we have associations valid in one place, at one time, and little concrete evidence to say if the outcome will translate to different contexts, or even endure over time in the context in which it is initially established.

At the same time, while qualitative work aimed at identifying and explaining pathways of impact can produce quantitative measures of impact, such work is often limited to very narrow populations or constrained geographic contexts. This can lead to challenges around the degree to which the findings of such qualitative studies can be applied to wider populations or geographic areas.

Therefore, while qualitative work on the pathways of impact is critical to the sorts of understanding necessary to make an evaluation a useful tool for learning and improvement, there are questions as to how broadly useful this information is, and what sorts of questions it can inform, outside of the immediate context in which such work was conducted.

The goal of CISRI's synthesis work on CIS evaluation is to combine ICRAF's and HURDL's independent efforts to identify ways of bringing together these approaches and their resultant data to address the challenges of external and internal validity that face each approach on its own. Specifically, this report had two broad and complementary goals:

- 1) First, we draw what lessons we can from combining the two studies. Despite their limitations and the lack of integration in design, we provide information that can significantly improve the effectiveness of the programs assessed.
- 2) Second, we use this experience to draw lessons for future synthesis efforts, both lessons for combining studies such as ours that have been imperfectly coordinated (these likely will continue to be the norm (Carr et al. 2017) and lessons to encourage better future coordination among assessment and learning activities.

3 Approach to Synthesis

The broad approach to synthesis in this report is drawn from the CISRI learning agenda on climate services users and needs (Carr et al. 2017), specifically the recognition that much of the learning around CIS design and evaluation will be drawn from ongoing projects, rather than from independent research. The synthesis efforts under CISRI mimic this situation, bringing together datasets from two imperfectly coordinated efforts to better understand the awareness, uptake, and use of CIS. A coordinated effort at synthesis was not a primary consideration in project design. While HURDL's work in Rwanda was purely related to the CISRI initiative, ICRAF was conducting a follow-up study of CSAI. In Senegal, while HURDL and ICRAF were both working under CISRI, part of HURDL's data collection came under an earlier initiative examining the need for CIS in Kaffrine. While aimed at the same projects, the two evaluation efforts synthesized in this report had different goals. ICRAF's work was aimed at identifying changes in agricultural and other livelihoods activities associated with the availability and use of information from climate services [cite ICRAF reports here]. HURDL's work focused on understanding the specific livelihoods contexts within which both projects operate, identifying what decisions are made, by whom, on what basis, and with what goals, and using this information to identify appropriate information to achieve development goals. With this information, HURDL both explained existing awareness, uptake, and use of CIS, and pointed to both barriers to and opportunities for wider and different uptake of that information to improve its efficacy and impact [cite HURDL reports here]. As both CIS were relatively new and lacked independent evaluations, both ICRAF and HURDL focused on identifying pathways and rates of climate information uptake among those targeted by these two CIS. ICRAF's data includes some quantified evidence for changes in livelihoods activities, and indirect evidence of changes in livelihoods outcomes. HURDL's work, which focused on elucidating livelihoods decision-making, was not aimed at determining quantified impacts of these CIS in terms of material livelihoods outcomes. A regrettable aspect of lack of coordination is that, as described in Section 4, the sample sizes for ICRAF's work in Rwanda were not sufficiently large for good comparisons with the HURDL Rwanda work.

3.1 Questions to Guide Synthesis

In this report, we approach synthesis through a series of questions. The first seven questions relate to the data gathered about the MWG model in Senegal, while question eight draws on data from both Senegal and the student of CSAI in Rwanda.

- 1) To what extent can we demonstrate that the two datasets represent the same population?
Working with the Senegal data, we establish the comparability of the populations represented in the two datasets through the following steps. First, we stratify the two populations using HURDL's highly contextual, holistic Livelihoods as Intimate Government (LIG approach). This stratification demonstrates that the populations represented in each study are similar in their distributions of perceived vulnerabilities and assets. Second, we use this same stratification only on that part of ICRAF's population that is not formally participating in the MWG program, and compare it to HURDL's dataset (as HURDL's work was conducted exclusively with those who were not yet participating in the MWG program) to double-check the comparability of the populations. As noted above, this comparison was only effective in comparing the two Senegal data sets.
- 2) What are the differences between those participating in the MWG program and those who are not?
This analysis, conducted by ICRAF, focuses on establishing any significant differences between these two groups represented in the ICRAF data, including livelihoods activities, crop selection, variety selection, and the use of weather and climate information. This step establishes the possible changes that require detailed explanation if we are to 1) attribute them to participation in the MWG program and 2) explain how the MWG program brought about these changes.
- 3) What differences between the MWG participant and non-participant groups can be attributed to the MWG, and in these cases how did the MWG bring about these differences?
Using the LIG data on livelihoods and livelihoods decision-making in one livelihoods zone in which the MWG has been implemented (FEWS-NET Zone SN10: Rainfed Groundnut and Cereals), we explore the possible pathways of change in existing livelihoods decision-making that might explain each identified difference.
- 4) Where there is a clear pathway, we attribute the difference to the MWG and ask what is the pathway by which the program brought about the change? Was it a change in decisions, a change in activities, a change in the actors making decisions, or other factors? In short, this will establish the extent to which each study reinforces the findings of the other.
- 5) Where there is not a clear pathway, we will revisit the LIG data to ask: what pathways might HURDL have overlooked? This exercise will improve the quality of the LIG analysis by identifying gaps in this analysis that might be filled. Where we identify new pathways by which the MWG might have brought about an observed difference, we will establish additional attributions and explanations. Where we cannot identify any pathway to explain the observed difference, we note that the difference cannot be rigorously attributed to the MWG.
- 6) What is the character of uncertainty around these findings? We characterize the uncertainty of our analyses and their synthesis to facilitate greater rigor in their interpretation.

- 7) What lessons can we draw about assessing impacts from the synthesis of these two datasets? There are two broad types of lessons we identify under this question. The first relate to the sorts of information that should be gathered/available to enable meaningful measurement of project impact. These include likely pathways of change, and what observed changes in variables mean with regard to behavior and decision-making. The second relates to how one productively synthesizes these different sorts of data. For example, this includes addressing discrepancies in the findings of different datasets.
- 8) What lessons can we draw about using the livelihoods zone, as defined by the Famine Early Warning System, as the scale of analysis? Previous analysis of CIS awareness, uptake, and use by HURDL worked in one or two communities representative of the demographics and livelihoods of a livelihoods zone, thus implicitly defining the livelihoods zone as the extent of validity for the findings. The concept of a livelihoods zone is central to the scalability of LIG and other livelihoods approaches: the dual assumptions are 1) that a relatively coherent and homogenous set of activities and conditions reflects a shared understanding of how to live, and 2) that the conditions for shared understanding can be located in geographical regions (Carr 2013). The Famine Early Warning System Network (FEWS-NET) bases its analyses around “geographic area[s] – known as livelihood zones – where people share similar livelihood patterns and access to markets” (<http://fews.net/livelihoods> accessed on 25 Oct 2018) and defines zones specific to each targeted country based on a set of agricultural and economic indicators. The synthesis of data and approaches in this report uses the FEWS-NET definitions of livelihood zone. By bringing together randomized survey data with a high degree of external validity for this zone and ethnographic data with a great deal of internal validity at the level of the communities in which they were gathered, it assesses the validity of the assumption that livelihood zones are the appropriate scale for the extent of validity of findings and, implicitly, assesses the suitability of the FEWS indicators as proxies for characterizing a livelihood zone.

3.2 Data Used in Synthesis

The data employed in this report was gathered to assess the awareness, uptake, and use of climate information associated with two CIS: the MWG model in Senegal and, to a lesser extent, the CSAI, and particularly the PICSA program used to circulate climate information and advisories. In Senegal, we focus intensively on a single livelihoods zone, SN 10: Rainfed Groundnuts and Cereals, allowing for the consideration of intra-zone variation that might challenge the external validity of assessments. In Rwanda, we use LIG data gathered in two livelihoods zones, RW 04: East Congo-Nile Highlands Subsistence Farming and RW 12: Eastern Semi-Arid Agro-Pastoral, to compare behaviors and outcomes across zones, providing an opportunity to test the proposition that these will differ across zones in the same country.

In Senegal, ICRAF collected data from 795 households in livelihoods zone SN 10: Rainfed Groundnuts and Cereals. The survey targeted heads of households or the second most important decision makers in each household. The main objective of this study was to assess the effectiveness of the MWG on farmers’ awareness, access and use of CIS (Chiputwa et al. 2018).

In Rwanda, ICRAF collected data from 684 households in seven livelihood zones, RW 03: Northwest Volcanic Irish Potato, RW 04: East Congo-Nile Highlands Subsistence Farming, RW 05: Central Plateau Cassava and Coffee, RW 06: Northern Highlands Beans and Wheat, RW 08:

Bugesera Cassava, RW 10: Southeastern Plateau Banana, RW 12: Eastern Semi-Arid Agro-Pastoral. The objective of the study was twofold: to assess the impact of climate services on the livelihood of farmers and establish the economic value of different climate services based on farmers' preferences (Coulibaly et al. 2018).

In both Senegal and Rwanda, HURDL employed the Livelihoods as Intimate Government (LIG) approach to develop ethnographic understandings of the decision-making behind observed livelihoods decisions, including the place of weather and climate information in those decisions (Carr et al. 2019). In Senegal, the HURDL team spent ten weeks in 2017 gathering observations and conducting interviews with 85 residents of the community of Panal, located in the northwestern part of the FEWS Zone SN10. The team also employed data from 44 interviews and associated observations gathered in 2013 from the community of Ngetou Malick, located in the southeastern part of the zone (Carr, Fleming, and Kalala 2016, 2015). In Rwanda, HURDL spent ten weeks conducting interviews with 87 individuals and gathering observations in the community of Kabeza, which represented Zone RW04. The HURDL team spent an additional ten weeks interviewing 88 individuals and gathering observations in the community of Gapfura, representing Zone RW12 (cite HURDL Rwanda Report here).

HURDL's goal was to develop behavioral baselines for each livelihoods zone from which we might explain the awareness, uptake, and use of weather and climate information. Behavioral baselines are understandings of the current structure of livelihoods decision-making in a zone. Understanding such decision-making is critical for understanding the impact of a CIS, as climate information produces observed changes when it informs livelihoods decisions in a manner that users can act upon.

4 Findings from the Synthesis

The bulk of our findings proceed from the work both HURDL and ICRAF undertook in Senegal. In Rwanda, HURDL collected data from two livelihood zones, while ICRAF collected from seven. The two overlapping zones between the two studies are livelihood zones RW 04 and RW 12. This effectively reduced the ICRAF sample that would have been eligible for use in this synthesis by over 60%. For the purposes of this synthesis, the analysis needed to be disaggregated first by livelihood zone, then by assemblages of vulnerability (as shown in Box 1 above) and last by whether the household is PICSA trained or not. This implied that the sample sizes of terminal groups to be used in the synthesis would have been too small to generate the statistical power to infer or generalize. Hence for the purpose of this synthesis, data from the Rwanda evaluation was dropped.

4.1 To what extent can we demonstrate that the two efforts represent the same population?

In Senegal, HURDL and ICRAF worked independently to gather their data. Both organizations focused their data collection in livelihoods zone SN10, and aimed at capturing a range of agroecological and market access conditions within this zone. Both sampled across a transect running from northwest to southeast to capture the precipitation gradient in this zone. This transect also includes communities with greater and lesser access to infrastructure and services associated with urban areas. Broadly speaking, each data collection effort gathered information about the livelihoods of those living in this zone, and their use of weather and climate information. We begin with brief descriptions of the data gathered by each team. We then discuss our efforts to determine if the data collected in these independent efforts represent similar populations within this zone.

4.1.1 ICRAF Data

Working within zone SN 10, ICRAF purposively selected one district covered by community radio where the MWG has been working since 2011 and another one without the MWG but still receiving signals from community radios. Those with the MWG are located in the Kaffrine region, in the rural communes of Kahi, Kathiote, and Mbignick. In each of these communes between two and four villages were randomly selected from a list of villages with a lead farmer, and two villages were selected from a list of villages without a lead farmer. In each of these villages, thirty farmers were randomly selected from the list of households provided by the village chief. The comparison district without the MWG is Guinguineo, located in the neighboring region of Kaolack (Figure 4.2). The ICRAF team focused its efforts in the rural commune of Panal Wolof. Panal is divided into 6 different quartiers. From these, eight villages were randomly selected. In each village, 30 households were randomly selected.

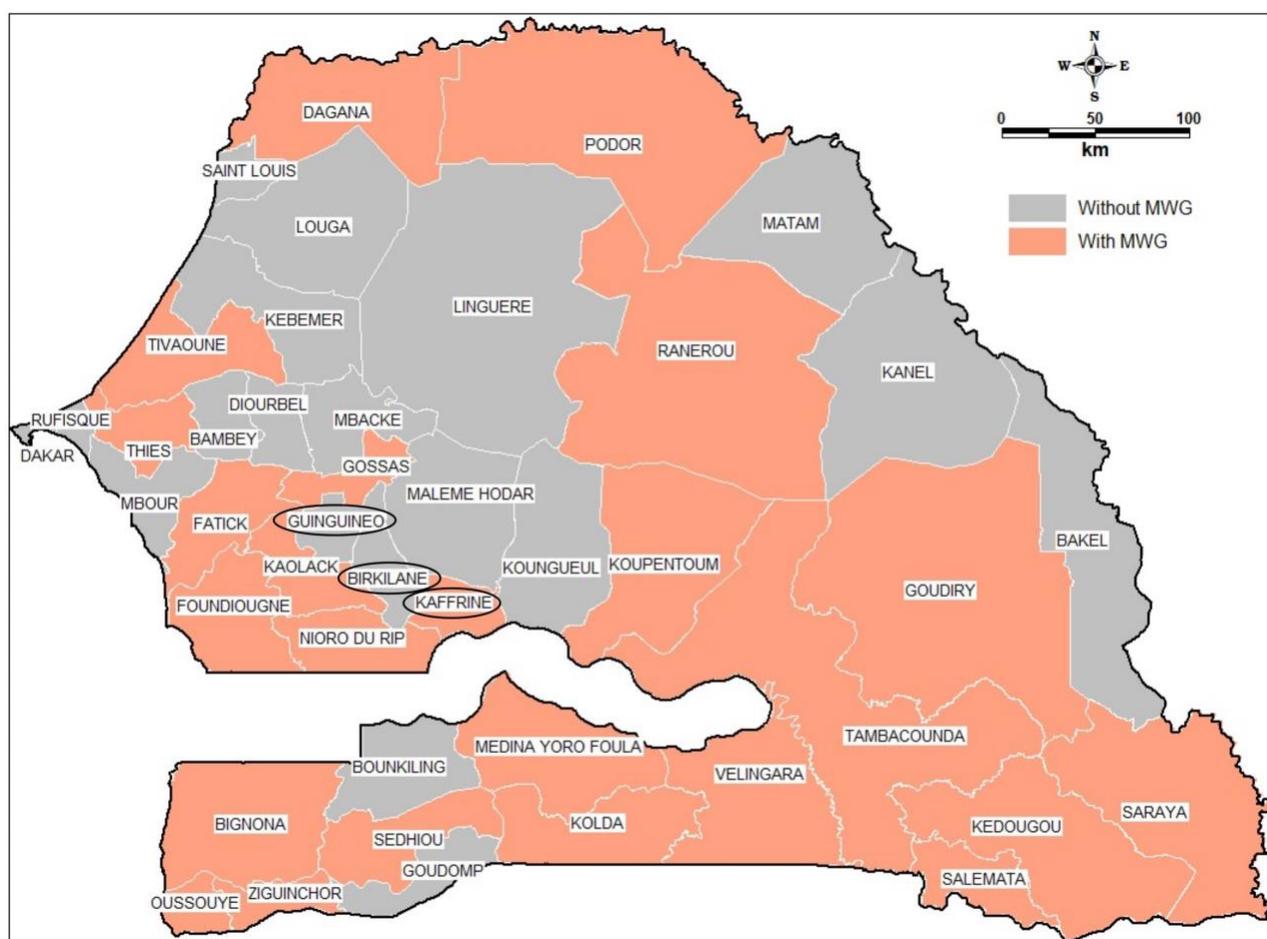


Figure 4.1: Map of Senegal showing the sampled districts (circled) and presence of MWG (Adapted from Ouedraogo et al. 2018).

ICRAF collected data through individual household surveys using structured questionnaires. The data was collected by ICRAF's local partners over a period of three weeks, under close supervision from ICRAF's socio-economic team. The survey interviewed the head (or second most important

decision makers) in each household, and a total number of 795 households were selected and interviewed during the survey.

4.1.2 HURDL data

HURDL's data was gathered in two communities in Zone SN10, Ngetou Malick (in the southeastern part of the zone) and Panal (in the northwest part of the zone) (Figure 4.2). HURDL examined the livelihoods of Ngetou Malick in 2013 as part of an assessment of the potential users for climate information in Senegal's Kaffrine region (Carr, Fleming, and Kalala 2015). Ngetou Malick was selected for its proximity and demographic/livelihoods similarities to other communities that had been engaged in the early stages of the MWG project in the Kaffrine commune of this region. Ngetou Malick is located approximately 9km from Kaffrine, the regional capital, along a well-maintained dirt road. During eight weeks of fieldwork, the HURDL team gathered data from 44 interviews and associated observational data.

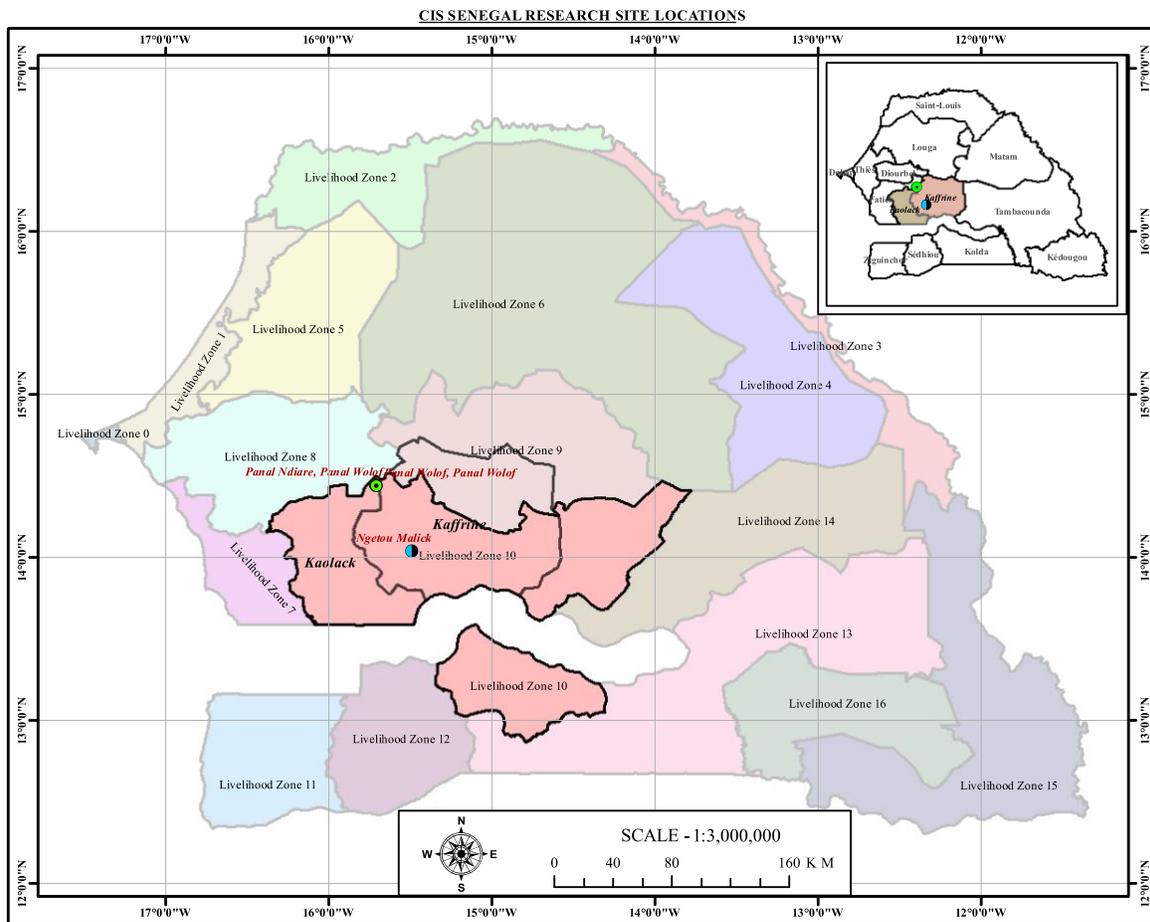


Figure 4.2: Locator map of Livelihoods Zone 10, and the villages of Ngetou Malick and Panal.

Panal is located in the Guinguineo commune, approximately 40km north and west of Ngetou Malick and 45km to the northeast of Kaolack. While this community is within Livelihoods Zone SN10, it is also on the border of Livelihoods Zone SN08: Rainfed Groundnut and Millet. Panal is much further from urban areas and has much weaker transportation infrastructure than Ngetou Malick. Further,

the precipitation gradient in this zone runs from northeast to southwest, with the northeast being the driest. As Panal sits very near the northeastern edge of this zone, this area receives less precipitation (400-500mm per year) than does Ngetou Malick (500-700mm per year) located further south and west toward the middle of the zone. It was selected by CISRI partner ICRAF as a comparative site for its biophysical similarities to the communities in the Kaffrine commune who have been engaged by the MWG. HURDL sampled in the same geography, and in some of the same communities in Panal. Over ten weeks of fieldwork, the HURDL team stayed in or visited each of the six quartiers to conduct interviews and gather observational data: Panal Gueyene (3 interviews), Panal Ndiaré (23 interviews), Panal Peulh (6 interviews), Panal Serrère (16 interviews), Panal Thiarane (15 interviews), Panal (22 interviews). According to residents of the village, Panal Thiarene is the largest quartier of the greater Panal village. Therefore, Panal and Ngetou Malick present a contrast of situations within the same livelihoods zone, an opportunity to assess the degree to which the structure of livelihoods decision-making varies within a given FEWS-NET zone.

4.1.3 Comparing the HURDL and ICRAF samples

The first task in synthesis was to compare the two independently collected samples to ascertain if they contained similar representations of the population in Zone SN10. Across both villages, HURDL stratified its sample using the LIG approach (Carr 2013, 2014), which considers assemblages of vulnerability (the set of vulnerabilities reported by individuals) and livelihoods asset ownership/access. This stratification builds on the fact that vulnerability is closely related to livelihoods, for as Gaillard (2010: 221) has argued, “assets and resources essential in the sustainability or unsustainability of livelihoods are conversely crucial in defining vulnerability. Such an intimate relationship between livelihood and vulnerability justifies that many people have no other choice but to face natural hazards to sustain their daily needs.” However, the LIG framework extends this exposure-centered framing of vulnerability to a contextual understanding of how different people in a population come to have different sensitivities and adaptive capacities to the shocks and stressors that mark their lives. As Bebbington (1999), Jackimow (2012), and Carr (2013) have argued, livelihoods are more than the means by which people make a living in the world. Instead, they are means by which people understand how to live in the world, how to order and make meaning in their everyday lives. Under LIG, this wider consideration of livelihoods as efforts to order the world allows us to connect material vulnerability to the social stresses that such vulnerabilities induce, such as threats to the authority of male heads of household that come about when they cannot feed their families, intimately tying individual vulnerabilities to this more holistic understanding of livelihoods. In this way, LIG recognizes that shocks and stressors can be endogenous to a livelihoods system, such as when women contest the authority of men to make decisions for the household. For men, this represents a stressor that influences their authority and identity, and thus presents a vulnerability they seek to manage through their livelihoods (Carr 2008, 2013). In short, LIG operates from a more holistic framing of vulnerability in its stratification of the population than do most other approaches to livelihoods and/or vulnerability. This effort produced a stratification of the population into three groups that shared broad assemblages of vulnerability: Surplus Production Livelihoods (SPL), Stable Subsistence Livelihoods (SSL), and Low Resource Livelihoods (LRL) (see Carr et al. 2019).

Group	Long Name	Animal Ownership	Agricultural Production	Nonfarm employment/ income
SPL	Surplus Production Livelihoods	<ul style="list-style-type: none"> - Draught animals, often more than one type - Various small animals that can be sold to meet financial needs or address shocks 	<ul style="list-style-type: none"> - Owns plows - Often owns additional equipment (seeder, cart) - Often cultivates millet, maize, and sorghum along with peanuts - Highest rate of gardening 	Significant engagement in business activities
SSL	Stable Subsistence Livelihoods	<ul style="list-style-type: none"> - Draught animals, usually only one type, and often only one animal - One other type of animal, often poultry but sometimes goats and sheep 	<ul style="list-style-type: none"> - Must borrow or rent plows and other equipment - Cultivates millet, maize, and some cowpeas along with peanuts - Minimal gardening 	Some business engagement
LRL	Low Resource Livelihoods	<ul style="list-style-type: none"> - Limited animal ownership - No draught animals - Very limited animal types beyond poultry 	<ul style="list-style-type: none"> - Must borrow plows and other equipment - Cultivates peanuts, cowpeas, and hibiscus, with little maize or millet production 	Business engagement similar to other groups, reports of work as agricultural laborers

Table 4.1: Assets and agricultural production characteristic of the three vulnerability groups identified by HURDL. These were associated with specific assemblages of vulnerability, which are discussed below.

After HURDL identified these three vulnerability groups, ICRAF sought to stratify its sample in a similar manner to enable comparison of the two datasets. To do so, it employed asset-based index approaches. The World Bank (2000) defines poverty as “pronounced deprivation in well-being.” A household is considered poor when its income or expenditure levels fall below a certain poverty threshold or line. For international comparison, the most commonly used measure of poverty is the \$1.25 per day international poverty line adjusted to economic units called Purchasing Power Parity (PPP), which considers currency differences and exchange rates. Measuring poverty in this way has often been criticized as being one-dimensional and ignoring other facets of vulnerability. In the absence of detailed information on household income or consumption there are several multidimensional approaches to the estimation of wealth and poverty that are based on household ownership of different assets, commonly referred to as asset-based index approaches, that are often used to provide a richer characterization of who the poor are (see Sahn and Stifel 2003 and McKenzie 2005 for a comprehensive review of asset-based measures, and Chiputwa and Qaim 2016 and Chiputwa, Spielman, and Qaim 2015 for empirical applications of TLU and household asset indicators). To stratify its data into vulnerability groups, ICRAF tested two commonly-employed tools for the assessment of wealth, the Tropical Livestock Unit (TLU) and the Household Productive Asset Index (HPAI). This effort, which links vulnerability to material circumstances, reflects common practice in the assessment of vulnerability and capacity of a population in development. To stratify its population, the ICRAF team constructed indices for both measures

(TLU and HPAI), compared the results, and selected the HPAI as the more holistic and productive measure.

ICRAF initially applied a normal distribution function to the HPAI scores of the individuals in the sample, creating breaks at one standard deviation above and below the mean, to divide the population into three groups which might have broadly shared assemblages of vulnerability. This is a simple and commonly applied method to determine the cut-off values for normally distributed data where the subjects were selected randomly. As this approach is purely a statistical one without consideration of site-specific conditions, there is a likelihood that some individuals may be classified into the wrong group.

It is therefore not surprising that HURDL’s LIG-informed stratification of the population bore little resemblance to ICRAF’s initial HPAI-informed stratification (Figure 4.3). Where the HPAI analysis suggested that the majority of the population in SN10 had what might be called Stable Subsistence Livelihoods (SSL) at the middle of the normal distribution, HURDL’s LIG stratification suggested that a majority of the population had Surplus Production Livelihoods (SPL), though it also showed significant variation in this distribution across the two communities sampled.

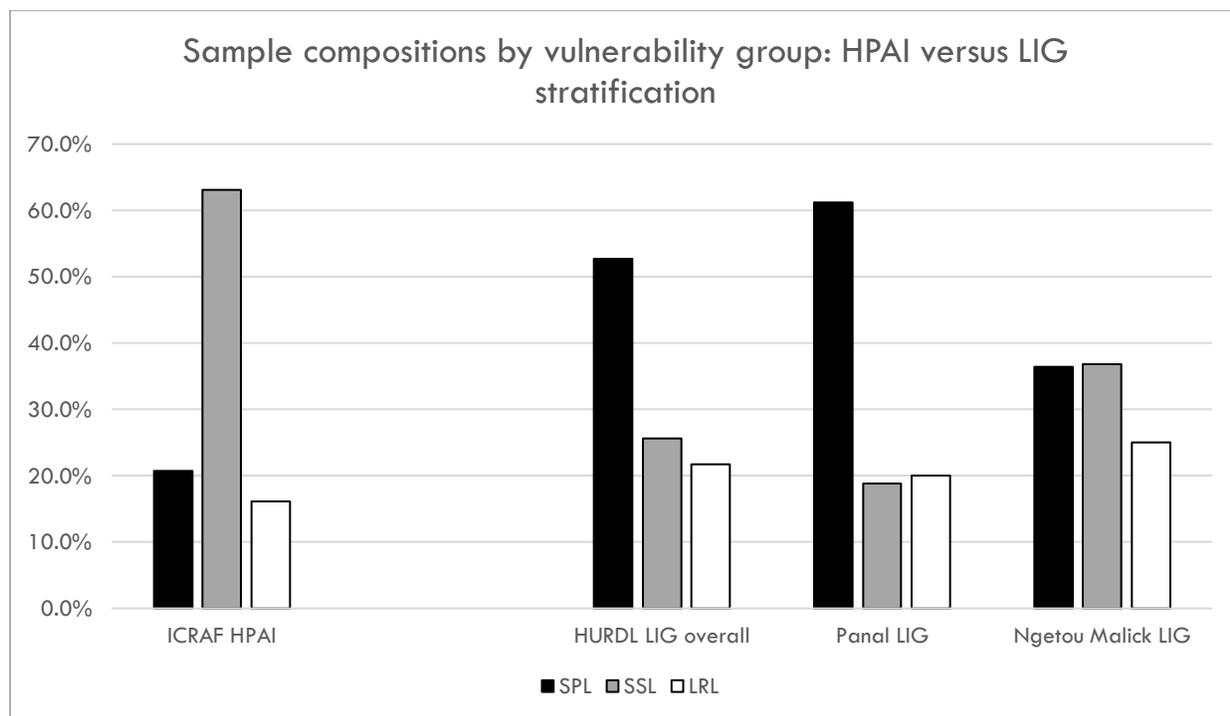


Figure 4.3: Comparison of the initial stratifications of the population into vulnerability groups by HURDL and ICRAF

While this initial comparison of stratifications appears quite disparate, the HURDL team noted significant similarities between its own data on asset ownership and that in the underlying data in ICRAF’s HPAI. Recognizing that ICRAF had not gathered detailed data on vulnerabilities, or on the more holistic context of livelihoods that shapes the perception of shocks and stressors as threats, HURDL provided a locally-specific asset-based proxy typology of each of the vulnerability groups as defined under the LIG analysis (see Box 1) in an effort to approximate this more complex stratification using asset information alone. If applied to HURDL’s data, this typology would produce a stratification very similar to that produced by the analysis which also considered reported

vulnerabilities. ICRAF used this proxy typology to re-stratify its sample. While ICRAF's re-stratification was necessarily coarser than the LIG analysis because it was forced to rely on asset ownership alone to proxy for the LIG stratification nuanced by vulnerability and identity data, it still resulted in a distribution of vulnerability groups very similar to that reported by HURDL (Figure 4.4). The fundamental difference between the two ICRAF stratifications is that the first assumed a particular statistical distribution (normal) of vulnerability and assigned break points based on the conventions of the normal distribution; the second stratification took its break points from proxy asset measurements suggested by HURDL that corresponded to HURDL's empirical identification of vulnerability.

Box 1: Creating parallel stratifications in the ICRAF and HURDL samples.

ICRAF did not gather data on individual assemblages of vulnerability, and so these could not be used to stratify ICRAF's sample in a manner parallel to that of HURDL. Instead, HURDL created a stepwise stratification protocol, using assets and crop selections associated with its groups as proxies for the more complex mix of vulnerabilities that drove the HURDL stratification. This process:

Step 1: Basic stratification into groups

A farmer has SPL if:

- Draught animals = yes
- At least one other type of smaller (goat/sheep/poultry) animal = yes
- Plow owner = yes

SSL:

- Draught animals = yes
- At least one other type of smaller (goat/sheep/poultry) animal = yes
- Plow owner = no

LRL:

- Draught animals = no
- Non-poultry other animals = no
- Plow owner = no

Step 2: Discerning where borderline cases should be grouped

If a case is between SPL and SSL:

- Those with more than one type of draught animal have SPL
- Those with more than one type of additional animal have SPL
- Those with additional agricultural equipment beyond plows have SPL
- Those who cultivate sorghum have SPL
- Those who garden have SPL
- Those who cultivate cowpeas have SSL

If the question is between SSL and LRL (you can rule out SPL):

- Those with animals other than poultry have SSL
- Those cultivating maize and millet have SSL
- Those who work as agricultural laborers have LRL

After using this process, ICRAF re-stratified its sample, and its distribution of the population across these groups closely resembled that in HURDL's sample (Figure 4.4).

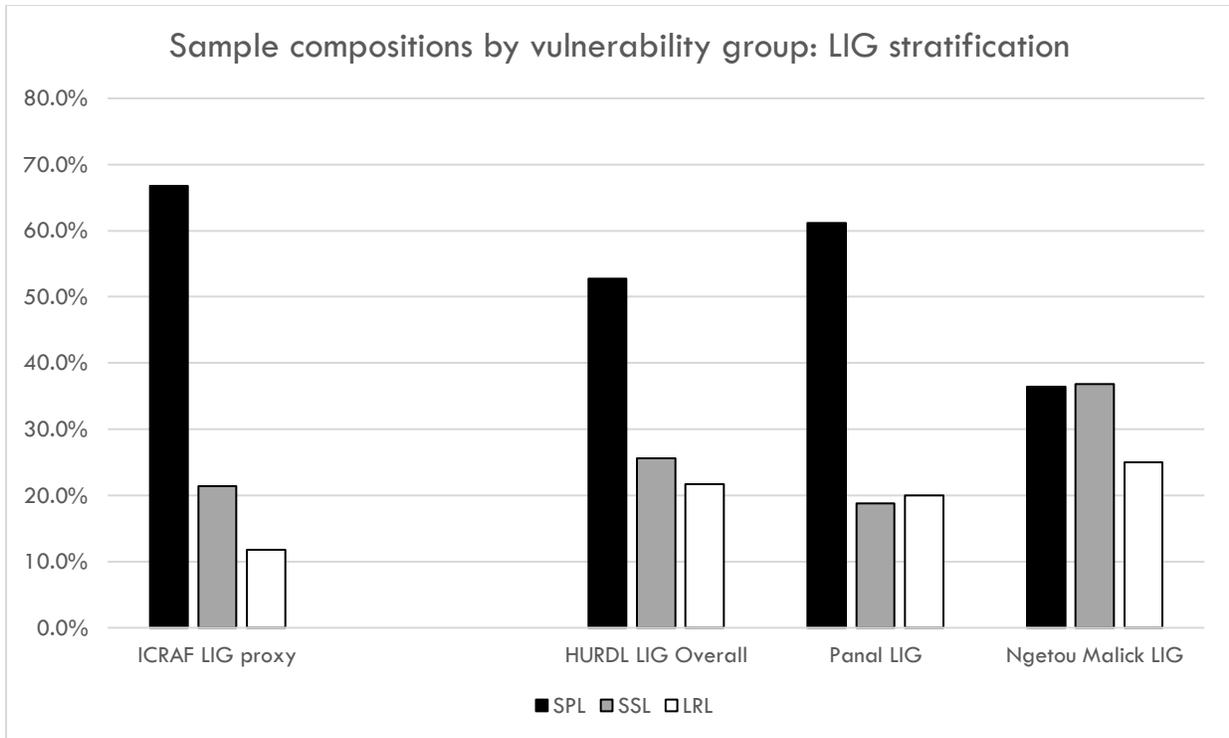


Figure 4.4: Comparison of the stratifications of the population after ICRAF applied a proxy of HURDL’s LIG stratification to its sample.

4.1.4 Comparing non-MWG samples

To ensure that the similarities in the stratification of ICRAF’s and HURDL’s populations was not an artifact of ICRAF’s larger dataset, which included individuals participating in the MWG and some who were not, ICRAF re-ran its stratification of the population on only that portion of the sample that was not engaged by the MWG. Figure 4.5 represents the results of that stratification, and shows that the non-MWG portion of ICRAF’s sample and HURDL’s sample produce very similar stratifications into groups by vulnerability.

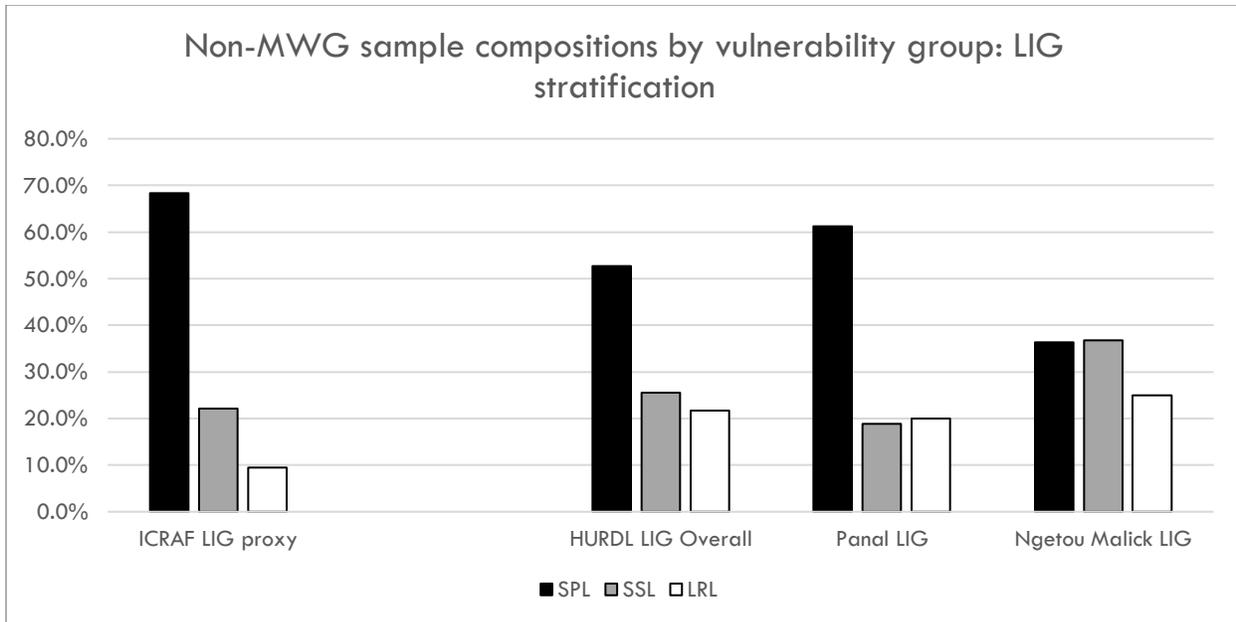


Figure 4.5: Comparison of the stratifications of the population without MWG after ICRAF applied a proxy of HURDL’s LIG stratification to its sample.

We also compared patterns of livelihoods activities, animal ownership, and crop selection visible in both datasets to better understand the extent to which the two samples resembled one another. We discuss these patterns in turn below.

4.1.4.1 Livelihoods Activities

The data collection strategy taken by the two evaluation efforts produced very different datasets on livelihoods activities for the otherwise similar populations. ICRAF gathered data on the livelihoods activities of the head of household. As the vast majority of the households they sampled were headed by men, their data is representative of senior men but not of women, or for that matter junior men. HURDL gathered data on the activities of all individuals interviewed, and therefore gathered a great deal of information on women’s livelihoods activities. For the purposes of assessing the similarity of these two datasets, we draw only on the men in HURDL’s dataset.

To compare the livelihoods activities represented in the two datasets, this data had to be aligned. HURDL gathered and reported its data in terms of discrete activities. ICRAF reported discrete (agriculture) and bundled (agriculture and livestock husbandry) activities. We disaggregated ICRAF’s aggregated categories and amalgamated them with the stand-alone categories to which they belonged (i.e. we took those who were reported as participating in agriculture and livestock husbandry and included them in both the agriculture category and in the livestock husbandry category). Also, there were issues in the ways in which either enumerators or respondents interpreted ICRAF’s questions. Only 17.4% of ICRAF’s sample reported participating in livestock husbandry, but 91.1% reported owning livestock and therefore clearly participated in its husbandry. This is an example of a common challenge to synthesis: different efforts that employ distinct questions to assess the same thing, whether vulnerability, livelihoods, or social roles, can produce very different understandings of the same phenomena. In this case, to address this challenge we adjusted the ICRAF data to reflect the ownership data instead of the participation data.

Figure 4.6 represents the reported rates of engagement in five major categories of livelihoods activity represented in both the HURDL and ICRAF datasets. These are broadly similar with regard to agriculture, animal husbandry, and day/wage labor. The HURDL dataset has much higher rates of participation in formal/artisan/business employment and has some gardening, while ICRAF's dataset has no gardening and very low rates of engagement in formal employment. It is not clear if gardening was an activity gathered by ICRAF, or why its dataset has such low reported rates of participation in formal/artisan/business employment.

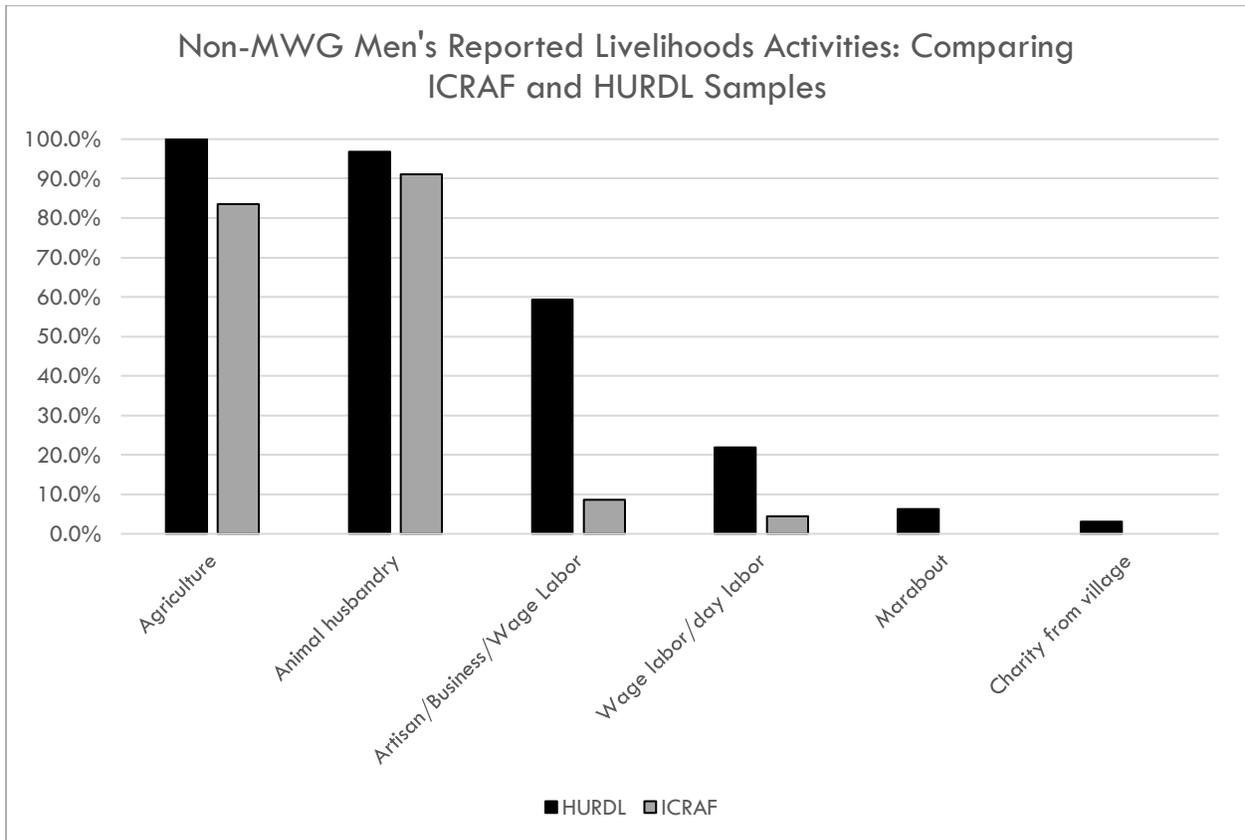


Figure 4.6: Comparison of men's reported rates of engagement in five major categories of livelihoods activity

While there are differences in these two datasets, they mostly appear in secondary activities. The datasets report very similar rates of engagement in primary activities like agriculture and animal husbandry, and similar rates of participation in day labor. The differences between these datasets are not large, considering the significant differences in the ways in which they were gathered.

4.1.4.2 Animal Ownership

Figure 4.7 compares the rates of ownership for different animals across non-MWG residents of Zone SN10. The ICRAF data returns higher reported rates of ownership than the HURDL data for nearly all animal types, but the relative rate of ownership of different animals is broadly similar (though sheep are much more popular in the ICRAF sample). This gap in reporting is similar across vulnerability groups. A comparison of reported animal ownership among those with LRL did not show a clear relationship across the samples. This may be a product of the relatively crude stratification of the ICRAF sample by asset-based proxies for HURDL's vulnerability groups, which may have included individuals in ICRAF's sample that would not have been found in HURDL's.

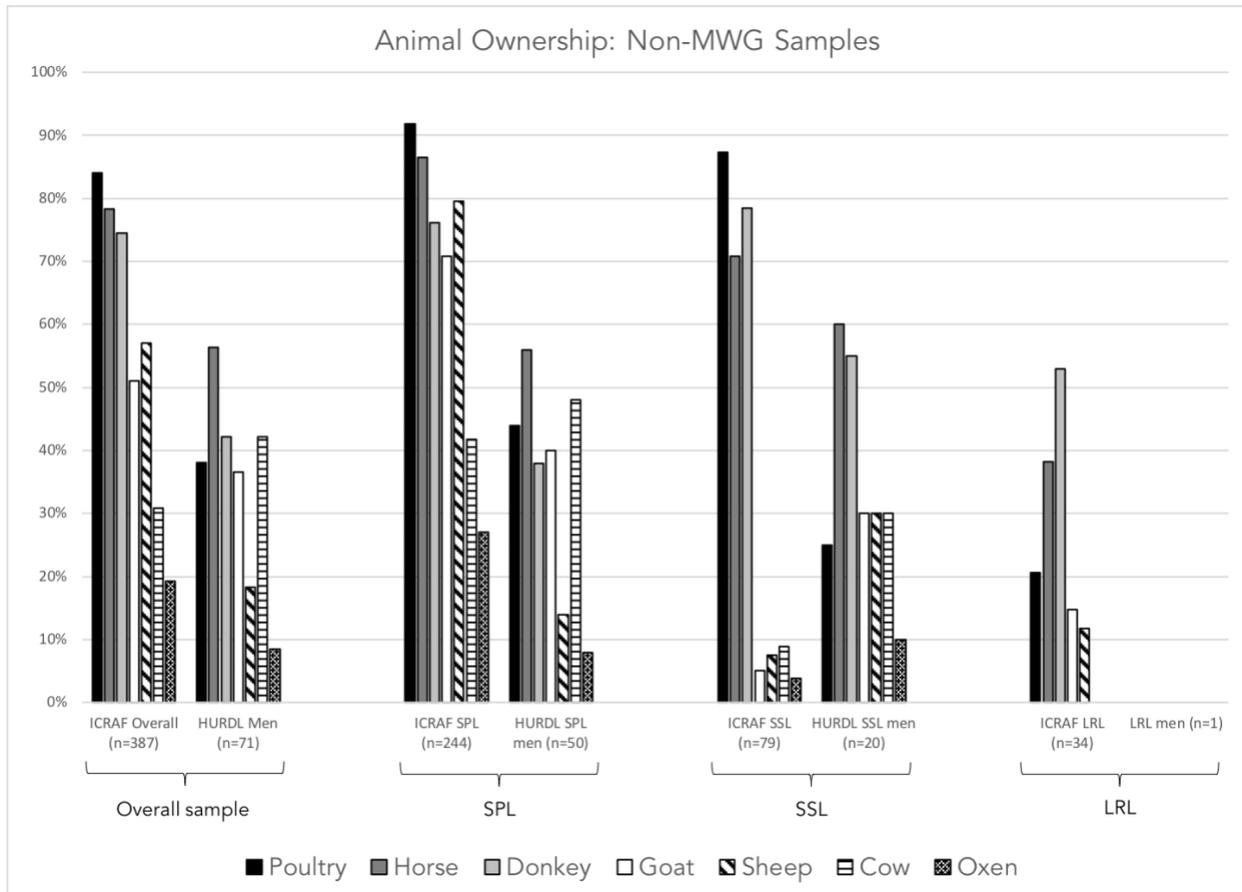


Figure 4.7: Reported rates of ownership of animals across the non-MWG components of the ICRAF and HURDL samples

The relatively consistent ratios of reported animal ownership across the two samples, whether as a whole or across those with SPL and SSL, is encouraging. It suggests that the much higher reported rates of ownership seen in the ICRAF data are likely a product of the different methods used to gather this data by the two teams. There are two ways in which the different approaches of the two teams might have produced this data artifact. First, ICRAF’s use of a survey likely prompted the memories of respondents in ways that HURDL’s open-ended conversations did not. Second, and likely more important, ICRAF explicitly focused on *household* assets, while HURDL focused on *individual* assets. The ICRAF teams asked heads of households to report on all animals owned in the household, while when HURDL’s field teams interviewed a man, they specifically asked about the animals those men owned.

Overall, the evidence suggests that HURDL and ICRAF were working with very similar populations. The two teams recorded similar *patterns* of ownership across different types of animals, and the differences in reported *rates* of animal ownership are artifacts of the different ways in which the two teams collected data.

4.1.4.3 Crop Selection

Figure 4.8 represents the rate of crop selection for three main staple grains in SN10, as reported in the non-MWG members of the ICRAF dataset and the men in the HURDL dataset. The patterns of crop selection are very similar across the two samples, and across vulnerability groups, though the fact there is only one man with LRL in the HURDL dataset makes the comparison of these groups across the datasets impractical. The ICRAF dataset generally reports a higher rate of millet selection than the HURDL dataset, while the HURDL dataset reports higher rates of maize cultivation.

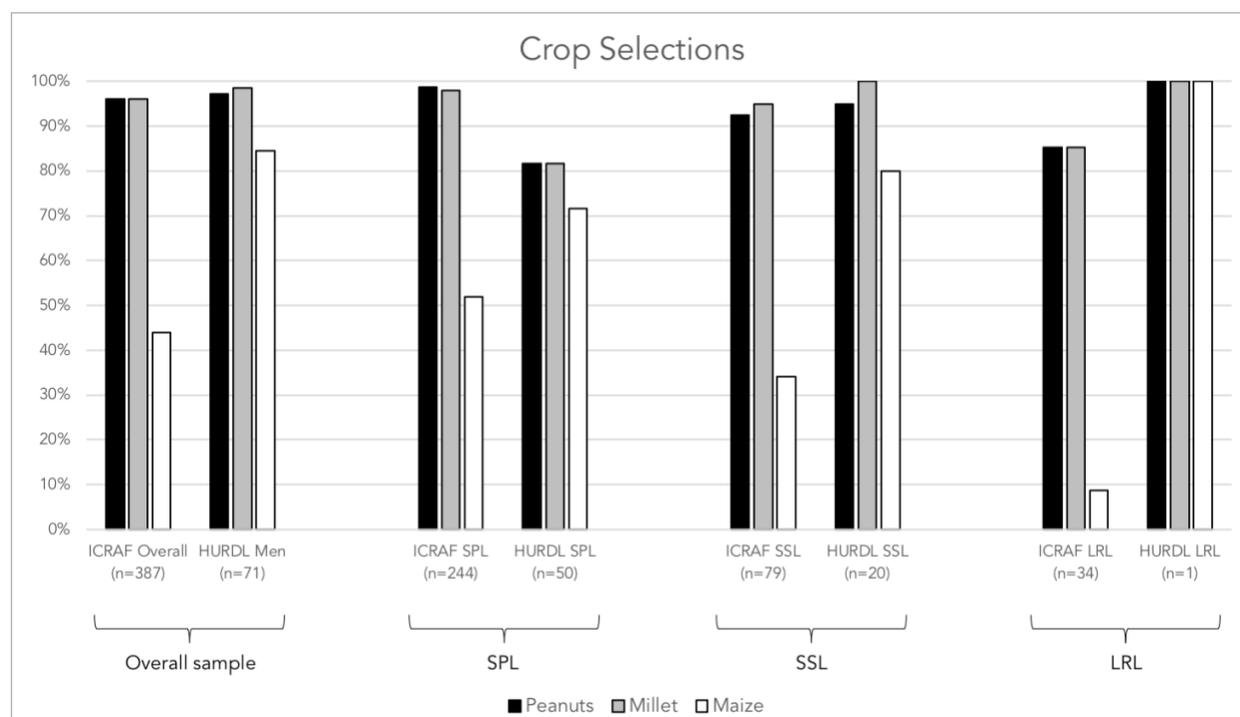


Figure 4.8: Rates of crop selection for three major staple crops across the non-MWG samples

The different reported rates of millet cultivation are likely artifacts of the differing agroecologies underlying the sampling. HURDL's data collection covered both the drier and wetter parts of the livelihoods zone, while ICRAF's non-MWG sample was drawn exclusively from the driest part of the zone. Millet is very resilient to limited and fluctuating precipitation, while maize is very sensitive to precipitation. The differing rates of cultivation for these crops appears to reflect the agroecological contexts in which the samples farm. Overall, the crop selection data also suggest that the HURDL sample and the ICRAF samples represent similar populations farming in somewhat different agroecological contexts, reflecting the fact that much of the non-MWG ICRAF sample lives at the edge of this livelihoods zone.

4.1.4.4 Summary of non-MWG comparisons

The men in the HURDL sample and the non-MWG portion of the ICRAF sample stratify into vulnerability groups in very similar manners. There are broad patterns of similarity across the livelihoods activities, animal ownership, and staple grain selection of the two samples. Further, in most cases there are clear explanations for differences between these patterns, such as the apparently lower rate of animal ownership and higher rate of maize cultivation in the HURDL sample. While there are some disconnects between the datasets, these are not so significant as to invalidate the use

of HURDL data to interpret patterns in the ICRAF data unless such interpretation hinges on the ownership of smaller draught animals such as donkeys. Taken together, these similarities suggest that HURDL and ICRAF sampled very similar populations across Zone SN10. As patterns of animal ownership and crop selection are the visible outcomes of complex livelihoods decision-making, and that the two samples display very similar patterns across these livelihoods decision-making outcomes, the data in this synthesis supports the contention that HURDL's detailed explanations of livelihoods decision-making represent larger patterns across sedentary agriculturalists in Zone SN10. This allows us to apply those detailed understandings to the differences ICRAF observed between MWG and non-MWG populations in this zone to explain those differences and whether or not they are attributable to the MWG.

4.1.5 Sample Comparison: Major Finding for Vulnerability Assessment and CIS Needs Identification

The parallel stratification of these two samples, using HURDL's nuanced LIG approach to divide the population into groups with broadly shared assemblages of vulnerability, strongly suggests that the two datasets represent very similar samples of the population in Zone SN10. It is likely that the use of asset proxies to stratify ICRAF's sample in a manner parallel to that of HURDL has slightly over-reported the number of households with SPL in ICRAF's sample, but the similarities between the distribution of vulnerability groups in the samples is evident. However, as both Figure 4.3 and Figure 4.4 show, HURDL's aggregate distribution somewhat obscures different situations across the livelihoods zone. Panal has a distribution of vulnerability groups very similar to that seen in ICRAF's overall distribution, while Ngetou Malick has a much more even spread of groups within its sample. However, on the whole the two samples reinforce the finding that, in Senegal's Livelihoods Zone 10, more than half of the population is relatively secure in their livelihoods, and seeking opportunities to increase their incomes and asset situations, while only between 10-20% of the population is extremely poor and asset-challenged, and therefore dealing with existential vulnerabilities.

The comparison of HURDL's highly qualitative dataset with the survey-derived dataset of ICRAF, provides us with confidence that these two datasets represent the same population within Zone SN10, and thus can be used in a complementary manner to identify and explain the impacts of the MWG on the lives and livelihoods of those who are participating in this program. However, this effort has also produced an important finding of the synthesis: **the estimation of vulnerability through the application of a contextual statistical analysis to asset-based indices is likely to misrepresent the distribution of vulnerability in a population.** As a result, such estimations are likely to misinform not only the design and implementation of CIS, but also the monitoring and evaluation of CIS. Monitoring and evaluation relies on understanding what to measure, and how to interpret any changes in those measures. If the basic assumptions about the vulnerability of a population that a CIS is intended to address are incorrect, monitoring and evaluation efforts are likely to be measuring the wrong things to assess impact. In this case, the use of a vulnerability assessment (which might be used to assess CIS needs) that relied solely on relative wealth as a proxy for vulnerability, and which assumes a normal distribution of vulnerability in the population, significantly overrepresented the level of vulnerability in the population when compared to a more contextually-informed stratification of vulnerability. There is no empirical basis for the assumption that vulnerability is normally distributed in a population, nor is there a theoretical justification for that assumption. Therefore, if asset-based vulnerability assessments use such distributions to stratify samples or identify vulnerable groups, they are likely misrepresenting the vulnerability of the

populations with which they work, and potentially misidentifying those vulnerabilities and the opportunities to intervene and address them. Instead the HURDL and ICRAF analysis demonstrates that effective CIS design, implementation, and monitoring and evaluation requires additional work to identify break points in asset-based indicators that correspond to the experienced circumstances of vulnerability and the concerns of a population.

4.2 What are the differences between those participating in the MWG program and those who are not?

In examining the impact of CIS on livelihoods decisions and outcomes in this livelihoods zone, we compare two distinct groups in ICRAF's sample: Those with access to the MWG, and who reported using the information from the CIS, and those without access to the CIS and who did not report using climate information. There were some in ICRAF's sample who had access to the information but did not use it (n=74), and some who did not have access to the full MWG process but heard forecasts over the radio and used them (n=277). To capture the impact of the CIS, we did not use these groups except as means of controlling for variations in agroecology and market access inherent to ICRAF's sample (ICRAF's report does address these groups in greater detail). In its analysis of the impact of the MWG, ICRAF used focus group discussions to identify three farm management practices, the use of improved seeds, the use of chemical fertilizers, and the use of manure, that might be most impacted by CIS. The selection of only three practices was partially driven by limitations of time, which did not allow for an expansive input-output module. These practices were evaluated both for all crops, and for the three most commonly-cultivated staple grains in the livelihoods zone: groundnuts, millet, and maize. ICRAF identified a number of differences in agricultural practice between those who were participating in the MWG program and those that were not. In this section, we describe these differences.

4.2.1 Use of Improved Seed

Figure 4.9 illustrates the differences in the use of improved seed identified by ICRAF through their survey. While the overall rate of improved seed use is low across both those with access to the MWG and who reported using the CIS and those without access to the MWG who did not report the use of CIS, the different rates of use among these groups is statistically significant at .01. By including those with access to the MWG, but who choose not to use the information, we can parse out the impact of agroecology on these results. In ICRAF's data, all of those with MWG access are located in the area around Kaffrine, which is much more proximate to an urban area and markets for improved seed than those in Panal. On one hand, it is clear that all of those with access to the MWG have higher rates of improved seed use, whether or not they use climate information. This strongly suggests that those living in the communities with access to the MWG also have greater access to improved seeds than their counterparts living in the more remote parts of the livelihoods zone. On the other hand, those using the climate information report the highest rates of use of improved seed, though the difference in improved seed use between those with access to the MWG and using the information and those with access but not using the information is not statistically significant.

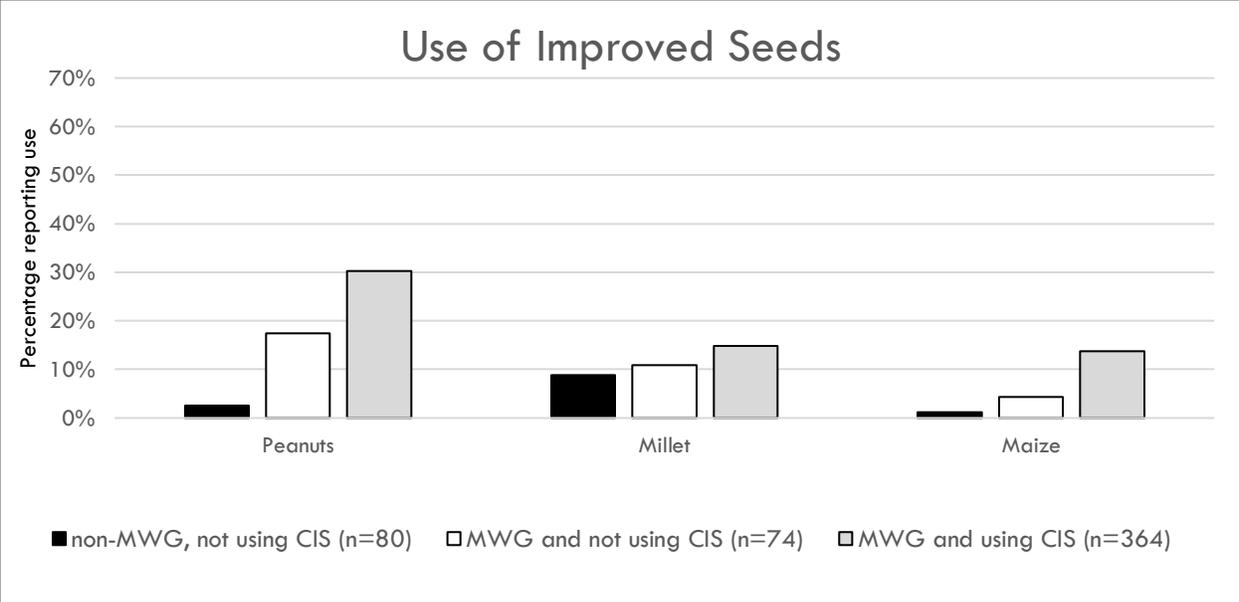


Figure 4.9: Reported rate of use of improved seed among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.

When we disaggregated the use of improved seed by vulnerability group, we find a consistent pattern: those with MWG adopt improved seed at a higher rate for all crops (Figure 4.10). This trend becomes more pronounced as the vulnerability of the household in question increases. Those living with LRL and not using CIS reported no use of improved seed, while those with SSL but not using CIS reported very minimal use of improved seed, and only for peanuts. However, in both of these groups when households reported using climate information, the use of improved seed either appeared or increased significantly. Therefore, there is a consistent relationship, across vulnerability groups and crops, between engagement with the MWG model and the increased use of improved seed. This pattern suggests that the connection between MWG access and use and increasing rates of improved seed use are the product of more than agroecology. Given similar access to markets, we expect that those with fewer resources and opportunities to control the timing of their agricultural activities would encounter local barriers to the use of improved seed that produced lower rates of use than among those with greater resources and latitude for decision-making. Instead, when using weather and climate information, the least-resourced respondents report the highest rates of improved seed use, suggesting the information is affecting their decisions about where to invest their resources.

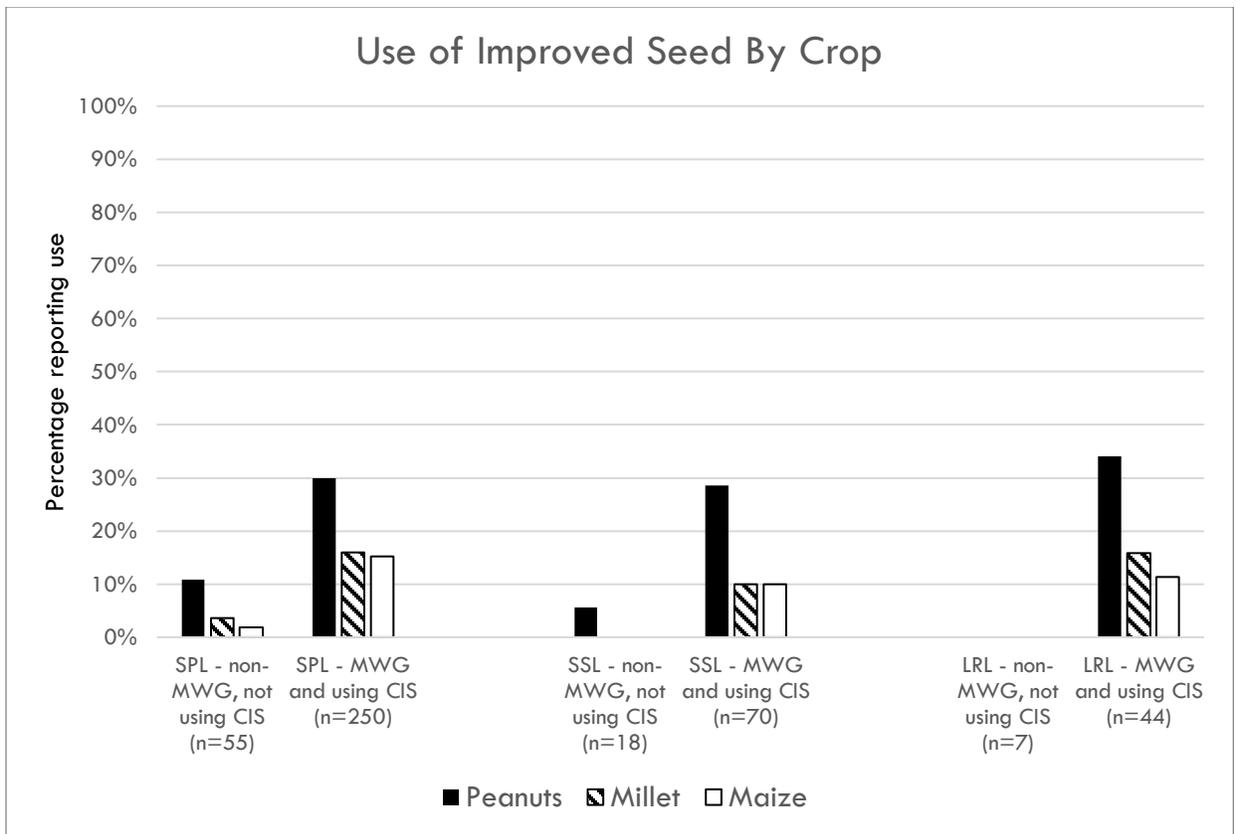
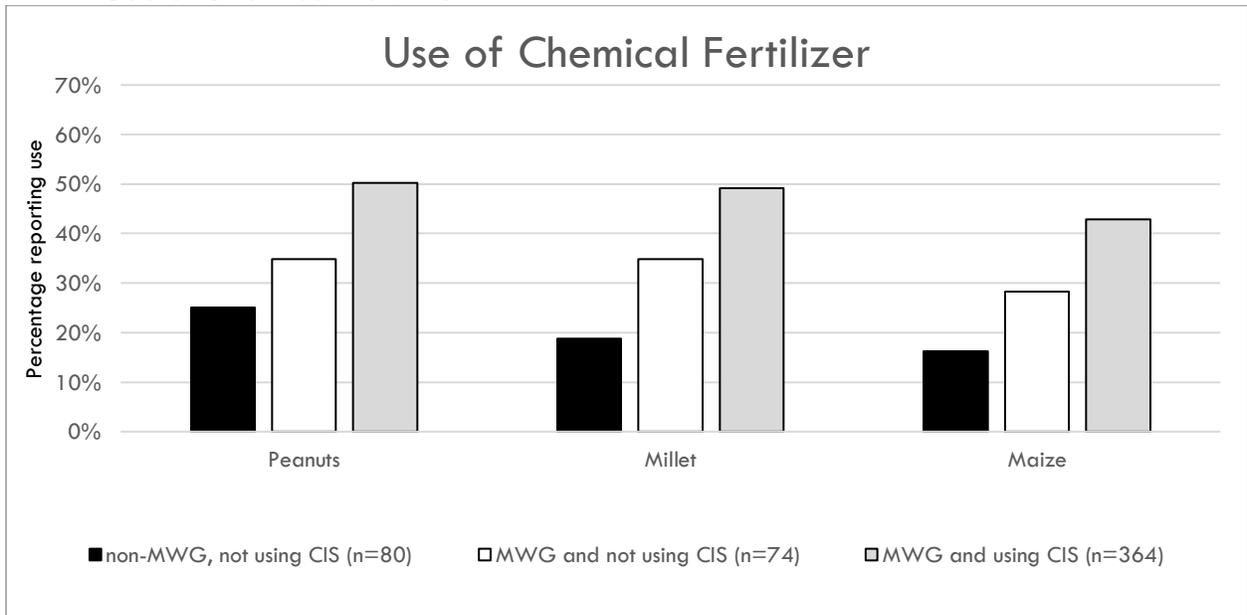


Figure 4.10: Reported rate of use of improved seed, by crop and vulnerability group, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.

4.2.2 Use of Chemical Fertilizer



shows the differences in the rate of chemical fertilizer use by crop, comparing those with MWG/using this CIS, those with MWG/not using this CIS, and those without access to MWG/not using CIS. While those using the CIS use chemical fertilizers on their peanuts, millet, and maize at

statistically significantly higher rates (significant at .01 for all three crops), only approximately half of farmers are using such inputs. As with the improved seed data above, those in the ICRAF sample with access to the MWG and who report using this CIS are also much closer to markets in which they might access fertilizers, while those without the MWG and who are not using CIS lack this ease of access. Looking at the patterns of chemical fertilizer use among those with access to the MWG, however, we can provide a limited control for the differences in access to markets in these two groups. The overall use of chemical fertilizer is higher among all of those with MWG access than among those without such access, suggesting that those with MWG access have greater access to markets for this fertilizer. However, those using the MWG report higher rates of fertilizer use, and these differences are weakly significant (at 0.1) for maize and peanuts. This suggests that the use of weather and climate information is associated with at least a small increase in the use of chemical fertilizers.

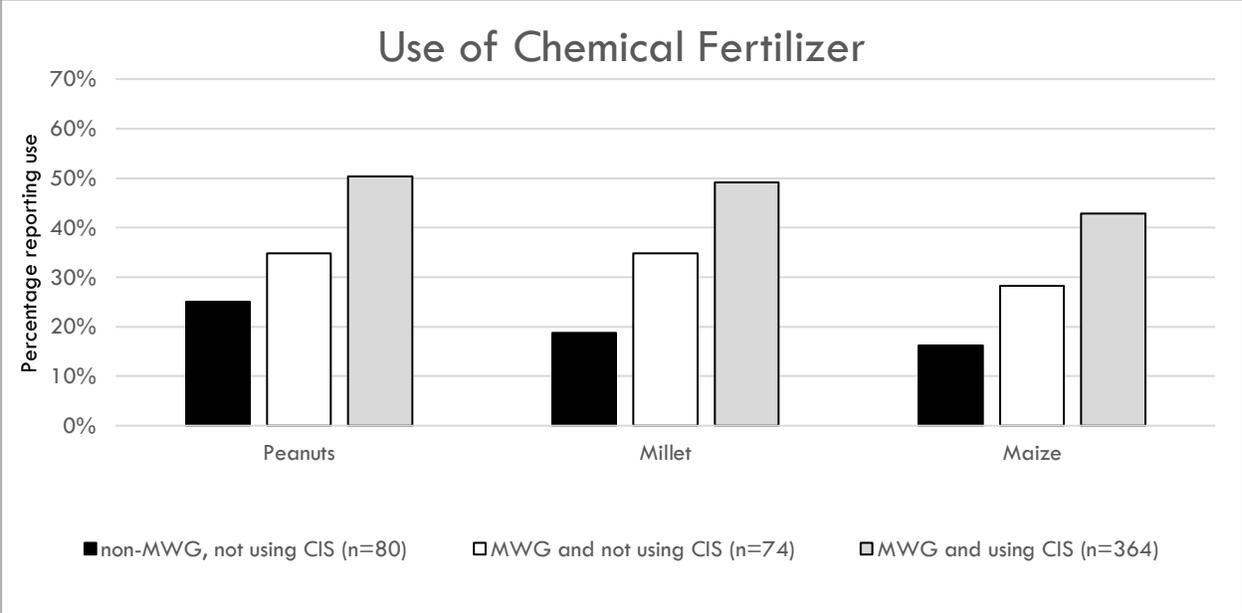


Figure 4.11: Reported rates of chemical fertilizer use by crop among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS

When we disaggregate the use of chemical fertilizer by vulnerability group, we find a similar pattern of difference across all groups (Figure 4.12). Among those with SPL and SSL, the use of climate information is associated with very similar differences in the use of chemical fertilizer, where those using climate information report rates of fertilizer use double that of those who are not using the information. Among those with LRL, those not using climate information did not report any use of chemical fertilizer. Those using the information reported rates of use similar to those seen among SSL households using climate information. Those with LRL who were using climate information reported somewhat lower rates of use of this fertilizer on maize, suggesting they were dedicating their limited resources to peanut (critical income) and millet (key subsistence) cultivation.

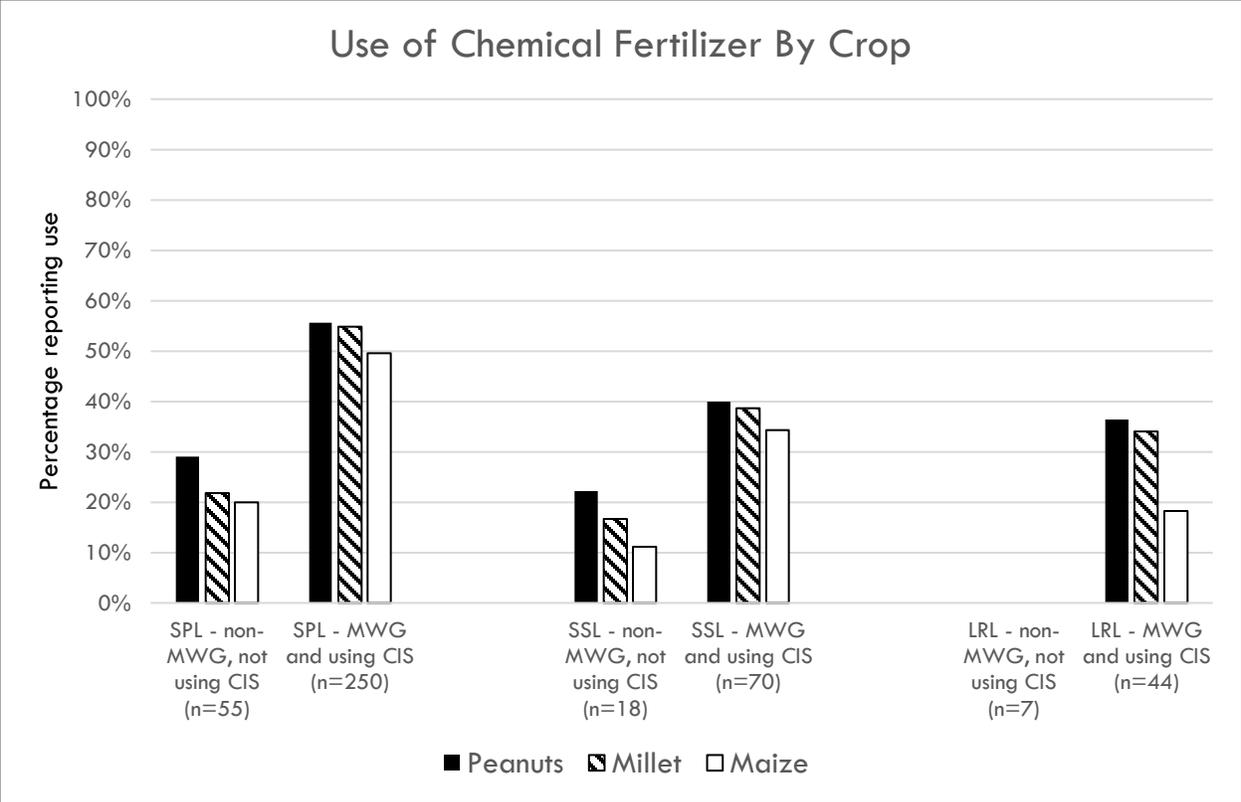


Figure 4.12: Reported rates of chemical fertilizer use by crop by vulnerability groups, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.

4.2.3 Use of Manure

The rates of manure use are very low overall and show little pattern of use among those with access to/using CIS, with access to/not using CIS, and those without access to/not using CIS (Figure 4.13). For those cultivating maize, the access to and use of CIS is correlated with a higher rate of manure use at a 0.1 level of significance.

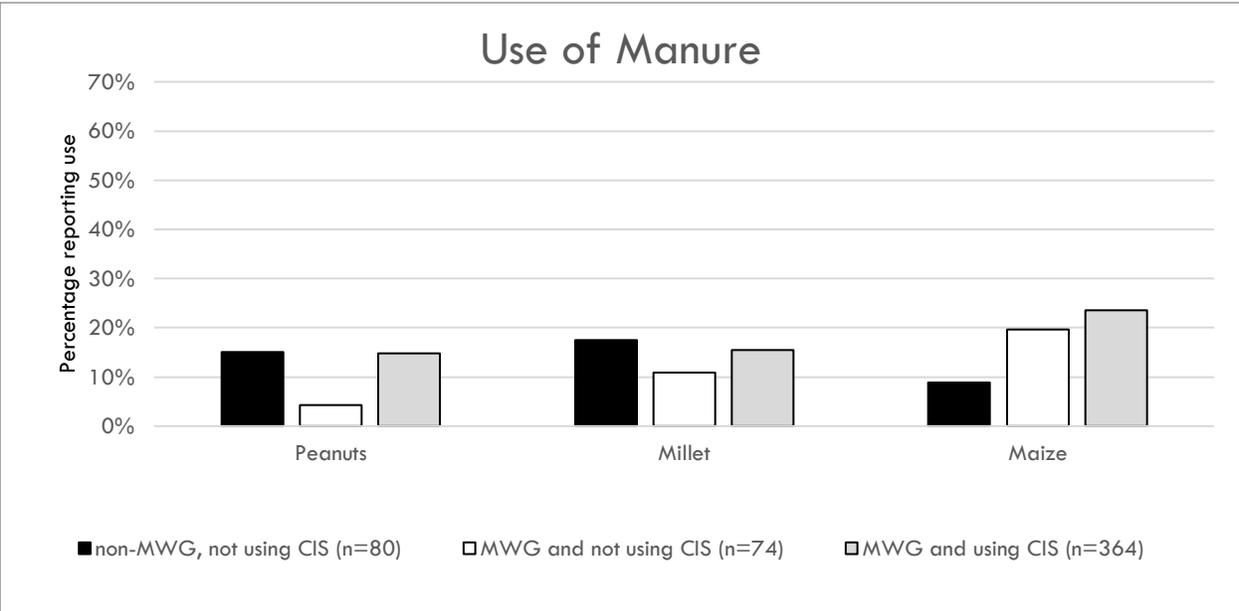


Figure 4.13: Reported rates of manure use by crop among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS

When we disaggregate the use of manure by vulnerability group, complex patterns emerge. Among those with SPL, the only change associated with use of climate information was a greater use of manure for maize. Those with SSL who used climate information reported lower rates of manure use on all crops, including a much lower rate of use on millet. For those with LRL using climate information, the use of manure on millet was lower than among those not using climate information. However, those using climate information applied manure to peanuts and maize, where those not using this information did not. Therefore, as with the use of fertilizer, the association between the use of manure and access to the MWG varies by crop and vulnerability group.

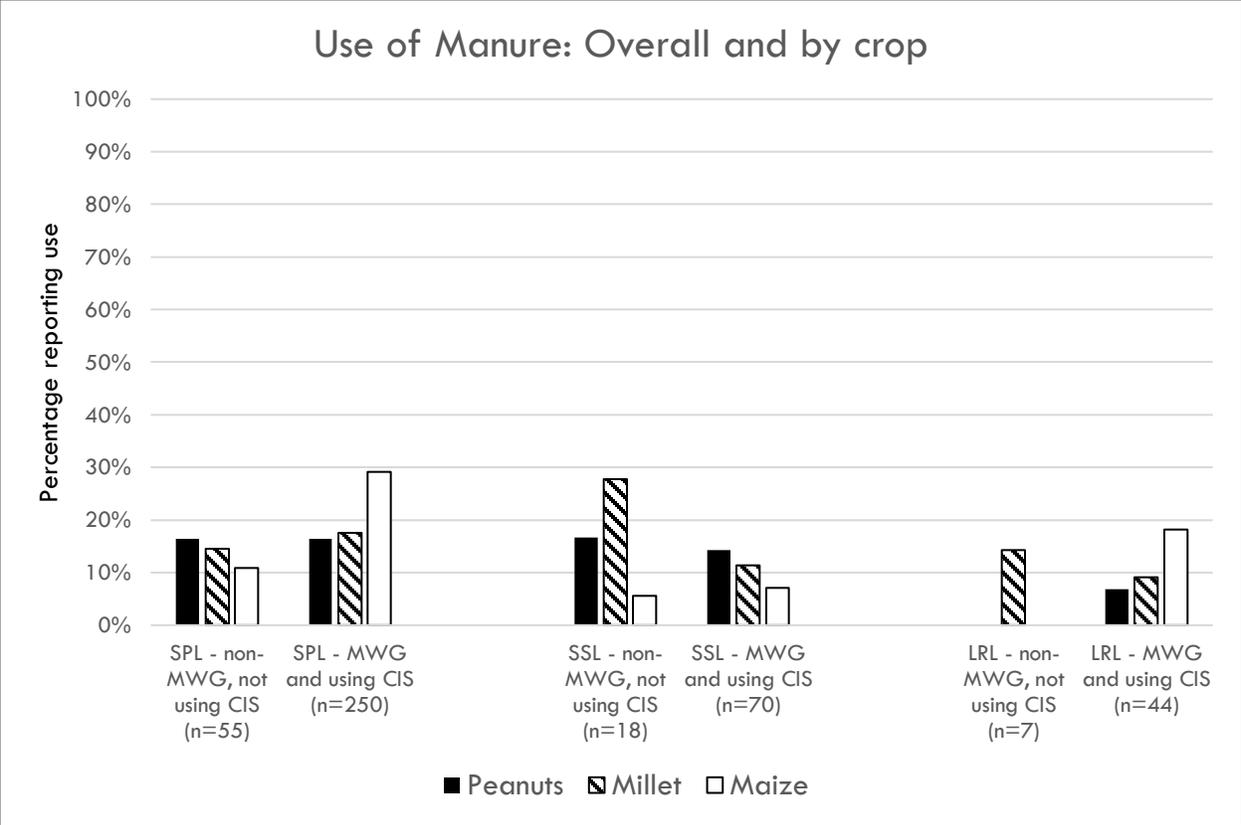


Figure 4.14: Reported rates of manure use by crop, disaggregated by vulnerability group, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS

4.2.4 Animal Ownership

One way of measuring animal assets is through the tropical livestock unit (TLU), a measure that weights different species, animal ages, and their market values to allow for an aggregate measure of asset value. ICRAF gathered data on animal ownership and constructed TLU measures across its sample. As Figure 4.15 shows, for those with access to the MWG, there is a significant (0.1) difference in TLU among those using the CIS and those who are not. Further, the TLU is lower among those with MWG access than among those without access, suggesting that neither market access nor agroecology is not the principle driver of changes in TLU. There is almost no difference at all in the average number of draught animals across these groups, suggesting that neither agroecology, market access, or climate information has an impact on ownership of these animals.

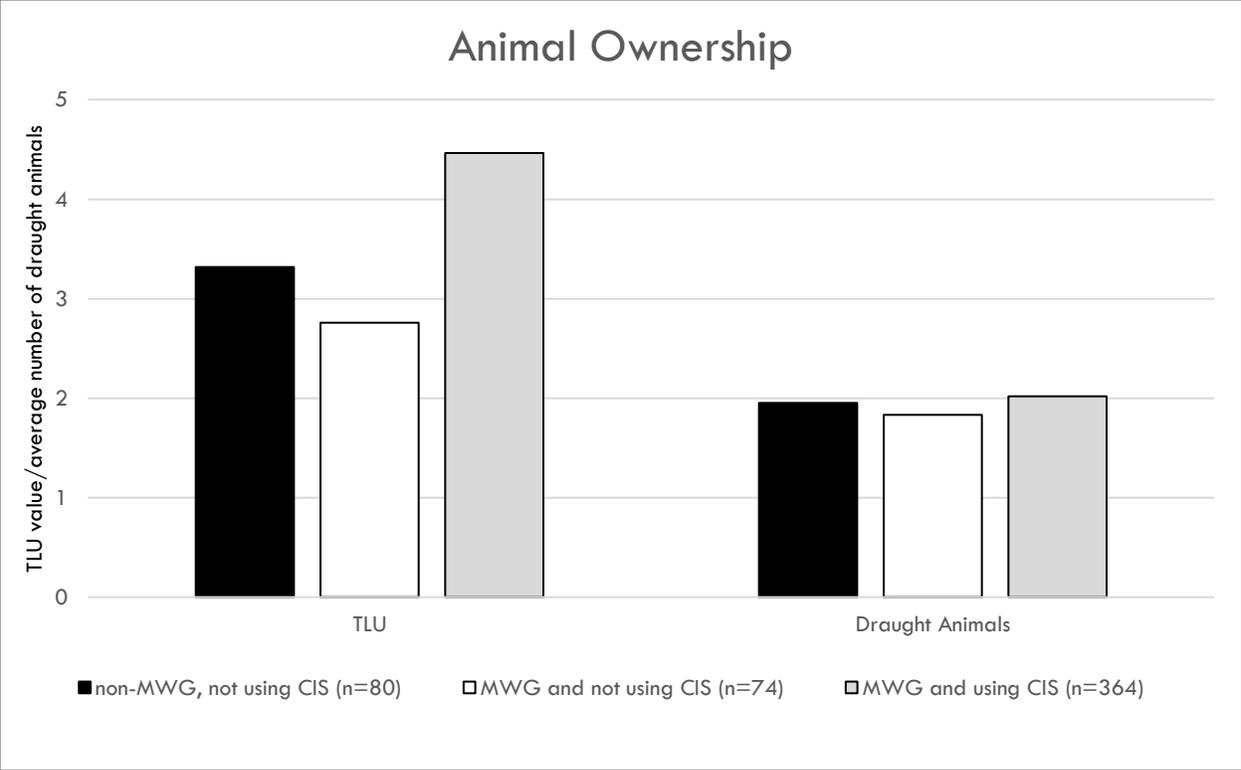


Figure 4.15: Reported rates of animal ownership among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS.

As shown by Figure 4.16, among those with SPL and LRL, overall animal asset value is greater for those who reported both access to and use of the MWG, though this difference is much more pronounced among those with SPL. For those with SSL, the value of animal assets is slightly lower among those reporting both access to and use of the MWG. This suggests that the value of climate information might be greater for those in asset- and income-secure situations, as they are better able to leverage this information into changes in their household asset situations.

Overall animal ownership speaks to the assets available to a given farmer or household. However, as has been demonstrated in other CIS studies (e.g. Carr and Onzere 2018; Carr and Owusu-Daaku 2016), the ownership of draught animals is often a specific factor shaping the use of climate information. Those without access to draught animals often cannot act on weather and climate information in a timely manner. Among those with SPL and SSL, there was almost no difference at all in the average number of draught animals owned by those with access to and using climate information and those who were not. Among those with LRL, those reporting access to and use of the MWG owned a slightly higher average number of draught animals.

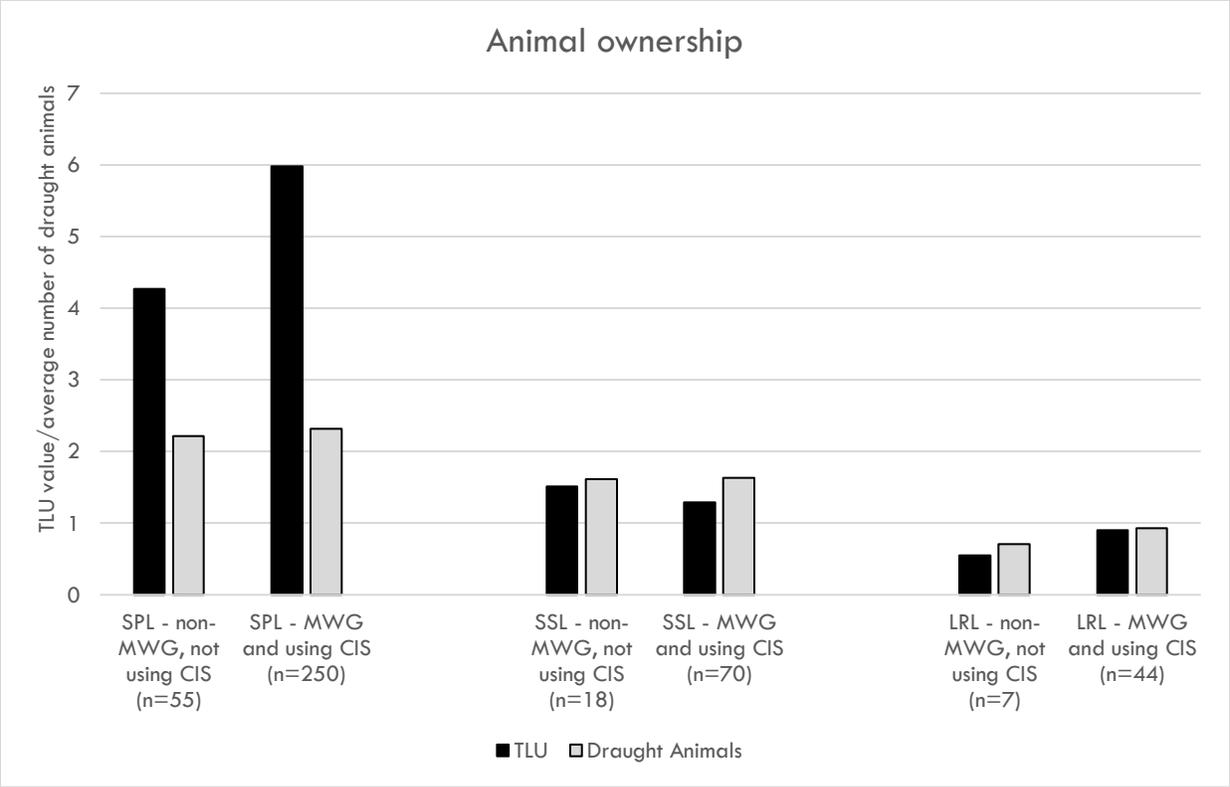


Figure 4.16: Patterns of animal ownership, including tropical livestock units and draught animal ownership, among those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.

4.2.5 Asset Ownership

Patterns of productive asset ownership are very similar to those described for animal ownership, especially TLU, described above (Figure 4.17). Those with access to the MWG, and who report using the information, have a much higher rate of asset ownership than those with access but not using the information, and those lacking access and not using information. Once again, those with access but not using climate information have a lower rate of asset ownership than those without access and not using information, suggesting that variations in agroecology and market access across the livelihoods zone do not account for the associations between the use of climate information and the accumulation of productive assets.

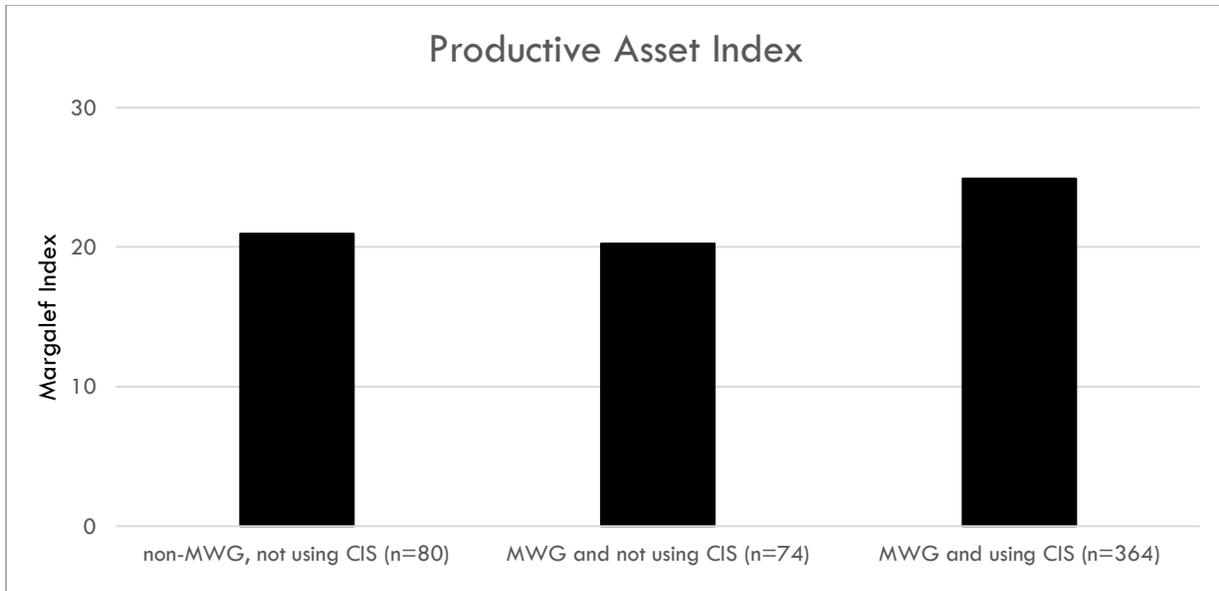


Figure 4.17: Reported rates of productive asset ownership among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS

The pattern of productive asset ownership across those with and without MWG access, varies by vulnerability group (Figure 4.18). For those with SPL, productive asset ownership is higher among those reporting access to and use of the MWG. There is very little difference in asset ownership associated with access to and use of the MWG among those with SSL. Among those with LRL, access to and use of the MWG is associated with a decline in productive asset ownership. As seen in the patterns of animal ownership, this suggests that the use of weather and climate information might have greater utility for those already in asset- and income-secure situations, while those in more marginal situations may lack the basic assets needed to take advantage of this information such that they can rapidly change their material situation. While this observation broadly reflects findings in the academic literature, we require more research to firmly establish the impact of this factor on uptake and use of climate information, as it suggests that CIS will not address vulnerability, build resilience, or help achieve development goals among those who lack the means to leverage that information to effect change.

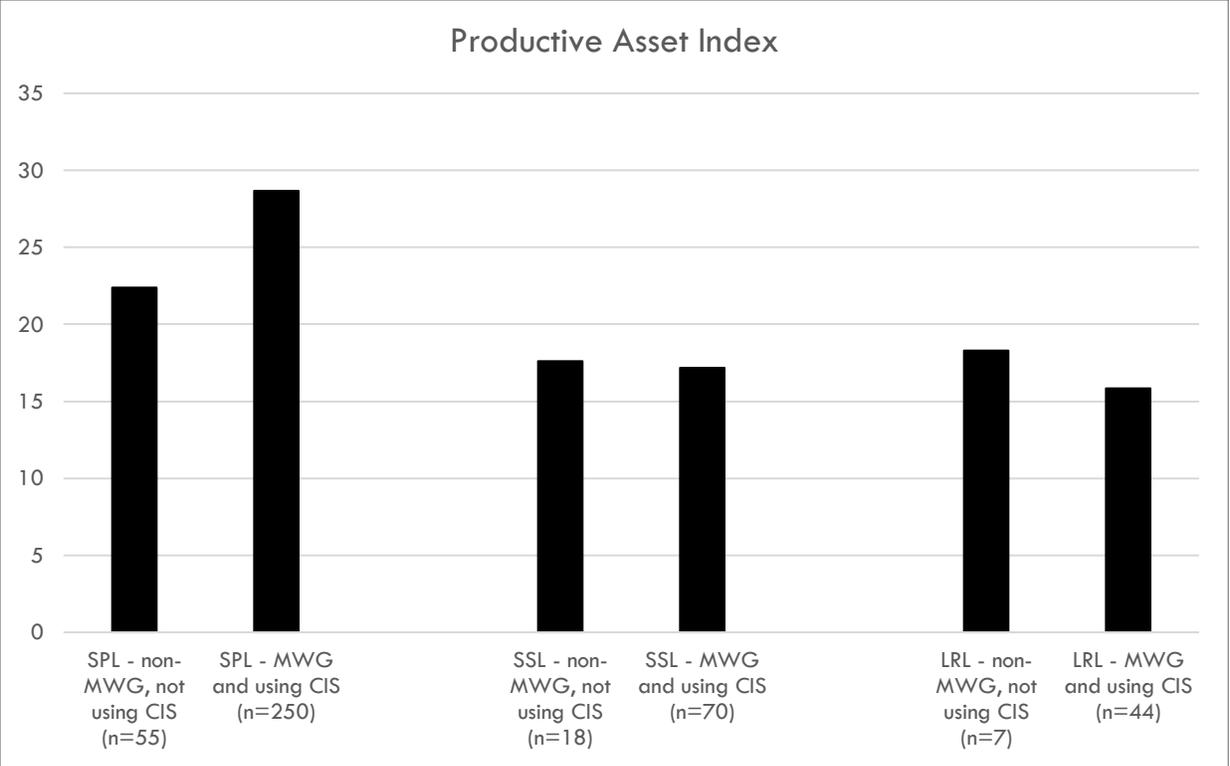


Figure 4.18: Patterns of productive asset ownership across vulnerability groups, comparing those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.

4.2.6 Crop Diversity

ICRAF constructed a Margalef index to capture the diversity of crops on the fields of the households it surveyed. One critical finding is that the diversity on the farms of those without access to the MWG, and not using CIS was significantly (.01) greater than that of either those with access and using the CIS or those with access and not using the CIS. This suggests that local agroecology may be driving crop diversification decisions in an effort to hedge against adverse conditions, and therefore in this sample those without access to the MWG will have a higher baseline of crop diversity than those with access to the MWG.

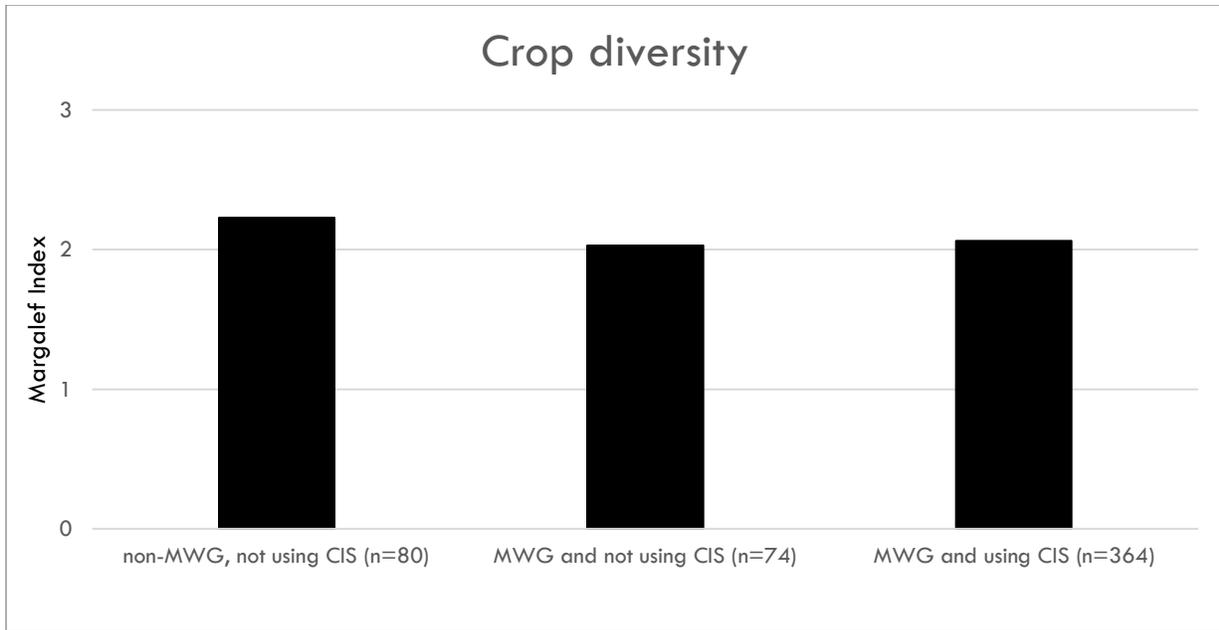


Figure 4.19: Reported rates of crop diversity among those with MWG access who reported using the CIS, those with access not using the CIS, and those without MWG access who did not report using the CIS

This index suggests that access to and the use of the MWG is associated with lower crop diversity across all three groups, though these differences do not rise to the level of statistical significance (Figure 4.20). Among those without access to and not using the MWG, those with SPL had the least diverse farms, and the difference in crop diversity between this group and those who reported access to and use of the MWG is the smallest of the three groups. Crop diversity was highest among those with SSL without access to or use of the MWG, and the difference between non-users and users of the MWG was largest in this group. Those with LRL fell between SPL and SSL with regard to crop diversity and the difference in diversity associated with the use of the MWG. With the data at hand, it is difficult to discern if this pattern is solely a product of differences in agroecology and associated livelihoods strategies in the different parts of this livelihoods zone, or if this pattern also contains effects produced by farmers who use weather and climate information to focus their production on fewer crops as they have less need to hedge against environmental uncertainty. While the effects of agroecology are clearly demonstrated in Figure X, the strategic value conclusion is supported by the fact those most secure in assets and income were already focusing their production on fewer crops. However, if this strategic effect exists, it is not large.

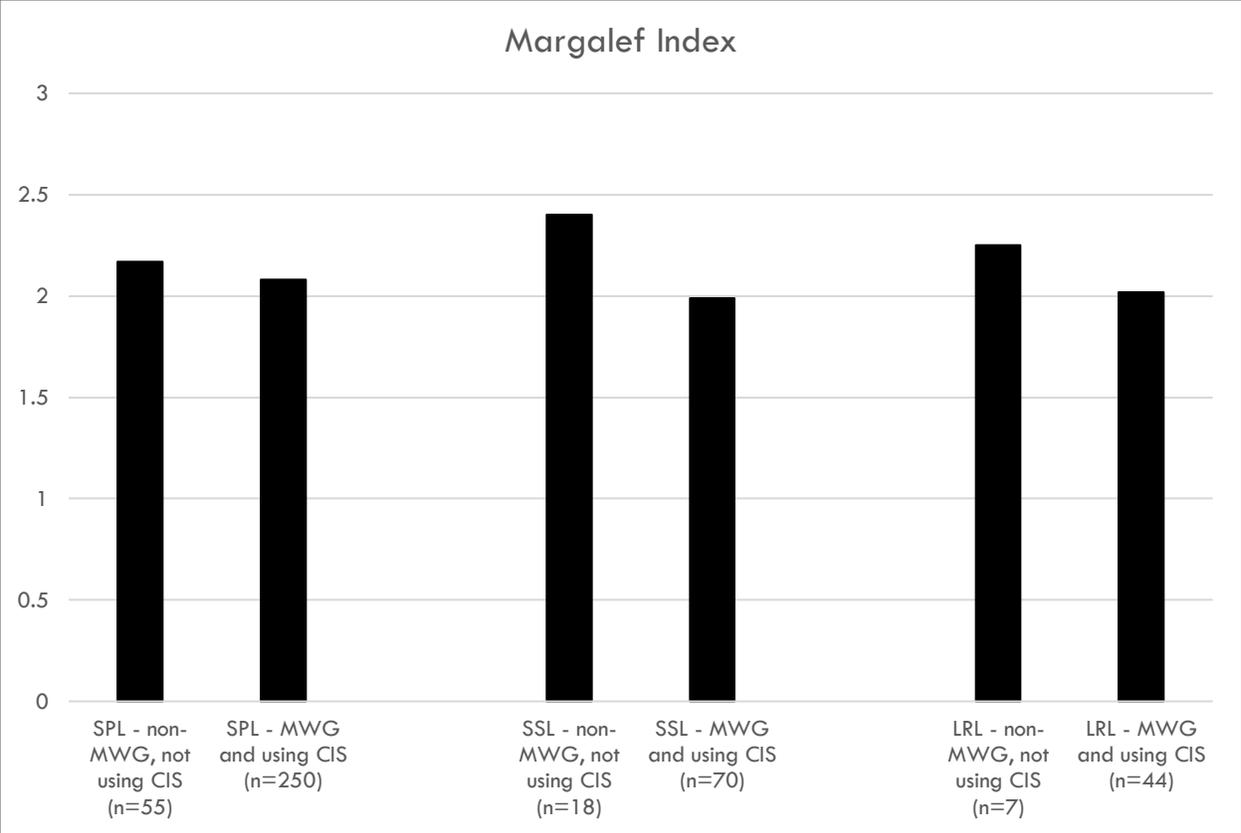


Figure 4.20: Margalef index of crop diversity measure across vulnerability groups, comparing those with MWG access who reported using the CIS and those without MWG access who did not report using the CIS.

4.3 What differences between the MWG participant and non-participant groups can be attributed to the MWG, and in these cases how did the MWG bring about these differences?

Error! Reference source not found. is a summary of the differences in agricultural practice observed by ICRAF. Broadly speaking, in the use of improved seeds and chemical fertilizers, there is a consistent pattern of higher use among those reporting access to and use of the MWG, and this pattern appears to hold even when we control for market access and agroecology. This is true across vulnerability groups and crops. The pattern of increase, which becomes more pronounced among farmers with fewer assets, is such that there is an overall trend toward an equalization in the rates of use of improved seeds and manure across vulnerability groups. For the use of chemical fertilizer, access to and use of the MWG appears to benefit the wealthiest and most secure disproportionately, a trend also visible in animal ownership and the productive asset index. In summary, the use of MWG information is associated with complex outcomes with regard to farming practice and livelihoods outcomes, at times appearing to be associated with an equalization of participation in activities and outcomes, and at others associated with an exacerbation of existing inequality.

Differences between those reporting access to and use of MWG and those without access or use

	Improved seed	Chemical fertilizer	Manure	Animal Ownership	Assets	Crop diversity
SPL	<p>Some increase in the use of improved seed is associated with those with access to and using MWG</p> <p>Greatest difference between non-MWG to MWG farmers is associated with maize (MWG is 8x higher)</p> <p>Smallest difference associated with peanuts (MWG is 2.75x higher)</p> <p>Millet difference in between (4.4x greater among MWG)</p>	<p>Those reporting MWG access and use report higher rates of fertilizer use, some of this difference is associated with the MWG</p> <p>The rates of use are higher by approximately the same amount across all crops</p>	<p>Those with MWG access and reporting use of climate information reported a slightly higher rate of manure use than those without</p> <p>The most substantial difference was seen with maize, where the rate of manure use nearly tripled for those using MWG information</p>	<p>Those with MWG access and reporting use of climate information had a substantially higher TLU</p> <p>There was almost no difference in draught animal ownership between those using the MWG and those who were not</p>	<p>Those with MWG access who reported use of the information had a higher HPAI than those without access and not using climate information</p>	<p>There was very little difference in crop diversity between those with MWG access who reported use of the information and those without access or use</p>
SSL	<p>Those with access to and using MWG reported much higher rates of use for improved seed, or the adoption of improved seed where before it was not used</p> <p>The use of improved peanut seeds is 5x higher among those with access to and using MWG</p> <p>Those reporting access to and use of MWG adopt improved seed for millet and maize, where those not using the CIS do not use improved seed for these crops</p>	<p>While overall rates of chemical fertilizer use are lower among this group than among those with SPL, those reporting MWG access and use also report higher rates of fertilizer use. This difference is partially attributable to the MWG</p>	<p>Overall, those with access to and reporting use of the MWG reported lower rates of manure use on their crops than those not using this information</p> <p>The rate of use on maize was slightly higher among those with MWG access who reported using the information</p>	<p>There was very little difference in either TLU or draught animal ownership between those with MWG access reporting use of the information and those who did not report MWG access or use</p>	<p>There was no real difference in HPAI between those reporting MWG access and use and those who did not have access</p>	<p>Crop diversity was lower among those with MWG access who reported use of the information and those without access or use</p>
LRL	<p>Those with access to and using MWG adopt improved seeds at similar or higher rates than those with SSL. Those not using the MWG do not use improved seeds</p>	<p>Chemical fertilizer adoption is associated with access to and use of the MWG information.</p> <p>No farmer reporting a lack of access to and no use of the MWG reported chemical fertilizer use</p> <p>Rates of chemical fertilizer use among those with access to and reporting use of the MWG were similar to those reported by those with SSL</p>	<p>The use of manure is much higher among those with access to and reporting use of the MWG information</p> <p>This pattern is marked by adoption of manure for peanuts and maize by those with access to and use of the MWG, while those without do not use manure on these crops</p> <p>Manure use for millet is slightly lower among those with access to and use of the MWG</p>	<p>Those with MWG access had a slightly higher TLU</p> <p>Those with MWG access had a slightly higher rates of draught animal ownership</p>	<p>Those with MWG access who reported climate information use had a slightly lower HPAI</p>	<p>Crop diversity was lower among those with MWG access who reported use of the information and those without access or use</p>
Overall	<p>General equalization of rates of use of improved seed across groups, though the poorest and most vulnerable appear to have benefitted the most</p>	<p>General higher rates of use of chemical fertilizer across groups, though the wealthiest benefitted more than other groups</p>	<p>General equalization of rates of use of manure across groups.</p>	<p>Inequalities between groups increase as those with SPL benefit the most, while other groups show little impact of climate information.</p>	<p>Inequalities between groups increase as those with SPL benefit the most, while other groups show little impact of climate information.</p>	<p>All groups reduce crop diversity in the presence and use of MWG information, but it is difficult to attribute this to the MWG.</p>

Table 4.2 Summary of the observed differences in agricultural practice in the ICRAF data

The associations described above are often statistically weak, and clouded by sampling issues that introduce differences in market access and agroecology to the ICRAF sample. However, we can use HURDL's LIG analysis in this zone (Carr et al. 2018; see also Carr, Fleming, and Kalala 2016) to address some of this uncertainty. HURDL's analysis projected a series of pathways of change in agricultural practice consistent with existing livelihoods decision making. While this analysis was more holistic than that undertaken by ICRAF, the analysis and its consideration of social roles and the representation of the value and appropriateness of activities by different people in the zone suggests ways in which the MWG data might inform decisions to change the rate of improved seed use and chemical fertilizer use. This allows for the attribution of the observed differences between those with and without MWG access through plausible pathways of change that might have produced the observed outcomes.

4.3.1 Surplus Production Livelihoods

HURDL identified this group as one where production was secure, and for whom the expansion of production was a primary goal. The level of security for this group was not uniform across the zone, as those in the northwestern, drier part of the zone owned fewer draught animals, and fewer species of draught animal, leaving them at risk to shocks that might kill or force the sale of that draught animal. Therefore, we expected that if the MWG provided useful, credible, salient information to these farmers we would see an expansion of agricultural production centered on peanuts, with crops like millet and maize of secondary importance. We also expected to see the accumulation of draught animals, and a diversification of draught animal ownership, especially as those in the northwest accumulated the resources necessary to purchase them. Among those with SPL, the data used to compare those with access to the MWG and those without yield patterns broadly consistent with HURDL's likely pathways of change.

Differences in the rates of improved seed use are consistent with HURDL's projected pathways. The largest difference across those reporting access to and use of the MWG and those who were not was in the use of improved peanut seed, with millet and maize also seeing higher rates of improved seed use, but rates approximately half that seen for peanuts. In this group, approximately half of those with access to and reporting use of the MWG apply chemical fertilizer to their maize, millet, and peanut crops. The rate of chemical fertilizer use was 30% higher for all crops among those using weather and climate information. While millet and maize appear to receive the most new input as a result of this trend, peanuts continue to receive the highest levels of fertilizer use by a very small margin. This is consistent with HURDL's analysis, which noted that while peanuts would be the initial focus of any efforts to boost agricultural yields, crops like millet would also see investment where possible. Taken together, the patterns of investment in improved seed and chemical fertilizer suggest that peanuts are still at the core of agricultural production in these households and are receiving some investment to boost yields, but that millet and maize are becoming more important crops in their livelihoods.

In this group, those reporting MWG access and use had much higher levels of animal assets overall than their counterparts without the MWG. However, the average number of draught animals was the same regardless of MWG access. HURDL's analysis anticipated the accumulation of animal assets, but the fact there is no increase in draught animal ownership among those with MWG access is difficult to interpret. HURDL anticipated some accumulation of draught animals in the northwestern parts of this livelihoods zone, as that was a critical vulnerability for this group in this

part of the zone, but the MWG has not yet been extended to this part of the zone, and so we do not know if this CIS will facilitate the accumulation of this critical asset. Instead, the measure here reflects those living in the center- to southeastern parts of the zone, where those with SPL already reported greater diversity of draught animal ownership. Further, HURDL's work found that those in the northwestern part of this livelihoods zone owned fewer, and a less diverse stock of, draught animals, rendering them more vulnerable to shocks. This is not reflected in ICRAF's data. This appears to be a difference in the two datasets, as opposed to something explained by access to the MWG. Overall asset ownership, at least as measured by HPAI, was also higher among those reporting access to and use of the MWG. As ICRAF did not gather sub-household data on asset and animal ownership, it is not clear who is accumulating these assets, and if that accumulation represents a change associated with this CIS. Further, ICRAF's and HURDL's datasets do not track change over time, and therefore cannot compare seasons to examine the impact of prior seasons on current investments in animals. For example, farmers may be less inclined to invest in draught animals after a series of challenging seasons where yields were limited and such animals did not produce a significant return on investment.

4.3.2 Secure Subsistence Livelihoods

HURDL defined this group as one where subsistence is generally secure, but a marketable surplus is not. Further, this group's pre-MWG livelihoods strategies exhibited concern for the risk of backsliding from a stable position to one of great stress and risk, such as experienced by those with LRL. If the MWG produced legitimate, credible, salient information for those in this group, HURDL expected to see agricultural efforts focus on the expansion of production, centered on peanuts. However, this expansion would likely contain a defensive component that would allow for the mitigation of any risk to overall harvests. Further, as among those with SPL, we expected to see increases in the number and diversity of draught animals owned by members of this group. Finally, we expected to see investment in plows and other major livelihoods assets. ICRAF's data suggests that some of these impacts have occurred, but that the MWG has not yet enabled major changes to the security of those in this group.

While market access clearly impacts the trends in improved seed use seen in the ICRAF data, those reporting access to and use of the MWG had higher rates of use of improved peanut seeds even when we control for market access. A few farmers with SSL who had access to and reported use of the MWG also adopted improved millet and maize seeds. This suggests that these farmers are using the information to implement a peanut-led effort to improve yields. The use of chemical fertilizers supports this interpretation. Even controlling for market access, the use of fertilizer is higher among those reporting access to and use of the MWG. Interestingly, the rate of fertilizer use for peanuts, millet, and maize are all higher by similar amounts (between 40% and 50% increases, even when controlling for market access), a pattern similar to that seen among those with SPL. Thus, among those with SSL it appears that MWG access and use is associated with impacts similar to those seen among farmers with SPL, albeit at lower rates. While those with SSL who are using the MWG have increased their peanut production, which represents an effort to increase incomes, they have also started efforts to shore up staple food production.

In this group, there is little difference in animal ownership between those reporting access to and use of the MWG and those without access and not using information. Further, there was no meaningful difference in productive asset ownership among those with access to and use of the MWG and those without. HURDL's analysis suggested that if the MWG provided useful

information, we would see at least men in this group move to accumulate more draught animals and durable livelihoods assets, like plows, to lower the precariousness of their agricultural practices. There is no such pattern in ICRAF's data. We suggest that this is explained by the fact that those in this group are not yet able to accumulate assets such that they can shift their animal husbandry strategy toward that seen among those with SPL, as they have in their agricultural strategy as evidenced in their use of improved seed and chemical fertilizer. The rates of animal asset ownership and productive asset ownership should be revisited in three or four years to see if the shift in agricultural strategy that appears to be taking place in this group produces enough change in yield to enable the accumulation of these assets. If animal asset accumulation becomes visible over a longer timeframe, it would suggest that in this livelihoods zone farmers accumulate assets through a specific hierarchy, starting with agricultural inputs and later moving to animal assets as their farm outcomes produce greater incomes.

4.3.3 Low Resource Livelihoods

HURDL characterized those with LRL as the most stressed residents of this zone. Their livelihood strategies were oriented around the management of risk, with little indication of investment that might produce changes in their precarious livelihoods. Because they lacked draught animals and plows, HURDL expected that members of this group would have a difficult time selecting new crops or crop varieties because they had to wait to cultivate until the necessary assets were available, leaving them to farm a very short season. If the MWG provided useful information that produced improvements in agricultural outcomes, we expected to see the accumulation of animal assets and perhaps durable livelihoods assets. For this group, however, ICRAF's data suggests that the MWG might be enabling more significant shifts in strategy than HURDL had anticipated with its analysis.

Among those with LRL, HURDL expected that any shifts in agricultural strategy would be defensive, as those with LRL face existential challenges such as food shortage on an annual basis, lack some or all of the agricultural assets necessary to use climate information in a timely manner, and have few assets upon which to fall back if the agricultural season goes poorly. The actual pattern among those with LRL is complex, but suggest that members of these households have much greater capacity to shift strategy than expected. Those reporting access to and use of the MWG reported rates of improved seed adoption similar to that reported by those with SPL. This is particularly impressive because no farmer with LRL reported using improved seed for any crop in absence of access to and use of the MWG. Those reporting access to and use of the MWG reported rates of chemical fertilizer use similar to that reported by those with SSL. Again, this is particularly notable because those without access to or the use of the MWG did not report any use of chemical fertilizer. Rates of manure use were somewhat different when comparing those reporting access to and use of the MWG to those who did not, with its use on millet lower for those with access and use. Overall, even when we control for access to markets, the patterns suggest that members of this group are using this information to inform the investment in seeds and inputs, including efforts to focus these investments to maximize outcomes.

Among those with LRL, those reporting access to and use of the MWG reported slightly higher levels of animal assets and rates of draught animal ownership. This is a positive difference that HURDL's analysis anticipated. However, these increases are very small, and as HURDL noted, they are not yet enough to change the precariousness of those with these livelihoods. In this group, however, productive asset ownership is slightly lower among those with access to and using the MWG, suggesting that expected investments in plows and other durable goods have not yet

occurred. This said, the differences in agricultural strategy seen between those without access to or use of the MWG and those with access and use suggests that members of this group are starting to leverage the information delivered by this CIS to shift toward somewhat less defensive livelihoods overall, a shift that might result in asset accumulation and greater security over a longer timeframe. Even when we control for market access and agroecology, ICRAF's data suggests that those with LRL are showing small benefits from accurate, actionable weather and climate information, which is more than anticipated by HURDL's initial analysis.

4.3.4 Summary: Impacts of the MWG in Zone SN10

The synthesis of ICRAF's and HURDL's data on the use and impact of the MWG in Senegal's Zone SN10 yields some broad findings about the impact of this program. We present these findings with confidence, as the patterns they represent were gathered, analyzed, and interpreted independently. Thus, where ICRAF's and HURDL's observations and interpretations coincide, we have confidence that we have identified an impact of the program.

- 1) **Access to and use of the MWG informs farmer efforts to invest in critical agricultural inputs such as improved seeds and chemical fertilizer, and appears to encourage such investment.** This pattern was most pronounced for the use of chemical fertilizer, which was substantially higher in the presence of MWG use across crops and groups. The pattern was less pronounced in improved seed, which may reflect either the presence of local varieties well-suited to existing environmental conditions, the reliability of different aspects of the CIS (for example, where short-term weather forecasts are very reliable even if seasonal forecasts are not), or local preferences related to taste or other crop characteristics which shape seed selection.
- 2) **The impact of the MWG on the overall asset situations of its users is not immediate.** Despite the observed changes in strategy described above, there was very little observed difference in animal or productive asset ownership associated with access to and the use of the MWG. We note, however, that this is a very new program, and most of those using it have only done so for a few seasons. Durable impacts on the asset situations of users may take several more seasons to become apparent. Instead, it appears that the impacts of the program are first visible in agricultural practice, and less durable investments such as seed and fertilizer, suggesting that in this zone farmers incorporate climate information into their decision-making through pathways that start with agricultural production, which then yields income that can be invested in durable assets.

Overall, this synthesis evaluation suggests that the MWG is already impacting user decision-making as farmers position themselves to increase yields across both cash and staple crops. For the more vulnerable in this zone, such positioning is a significant risk, suggesting that these farmers see the MWG as credible and salient. We believe it is too soon to identify or assess the impact of the MWG on the overall livelihoods of those in this zone because these impacts have not yet had time to emerge. However, should the patterns observed in this evaluation endure, we expect to see such impacts emerge in the next three to five seasons. Should these patterns prove ephemeral, it might reflect farmers abandoning the use of the MWG, which would cast doubt on its credibility and salience. Many potential impacts of the MWG, however, are contingent on non-MWG factors. If this zone sees an epidemic that strikes animal assets, a significant season or seasons of challenging weather, or one or more extreme weather events, the accumulation of assets could be delayed as those living in this zone manage these impacts. Therefore, over a longer timeframe the evaluation of MWG impact should be calibrated to these sorts of events, as understanding what to measure to

appropriately capture impact is critical to the assessment of the value of the MWG. While we expect to see asset accumulation in the context of a series of normal to favorable seasons, we also expect that the use of the MWG will allow farmers to avoid loss and the negative impacts of the shocks and stressors described above.

5 Lessons about assessing impacts from the synthesis of these two datasets

While the assessment of impact will be facilitated by the design of CIS where baseline data on agricultural and livelihoods decision-making and outcomes can be collected and compared to post-intervention outcomes, this aspect of design is not in itself sufficient for establishing CIS impact.

5.1 Sample stratification

Baselines and subsequent data must represent the situations of different users of CIS in the population, and the different needs of those users. As demonstrated in Section 4.1.3: [Comparing the HURDL and ICRAF samples](#), meaningful stratification requires empirical evidence for the distribution of vulnerability and resilience in the population and for break points where decision structures might change. There is no reason to assume that vulnerability (or resilience) are normally distributed in an agrarian population.

Many datasets on potential users of CIS will not have detailed information on their vulnerabilities, making the stratification of users described here difficult. As we have demonstrated in this report (see Section 4.1.4), however, it is possible to conduct a detailed, qualitative vulnerability assessment and use that to stratify a representative set of users. After doing so, one can construct proxies in terms of things measured in the larger dataset, such as the asset proxies described above for stratifying ICRAF's data. Such proxies can yield stratifications for much larger populations very close to those obtained through qualitative research in specific communities.

The work of HURDL in Zone SN10 (along with work in other livelihoods zones, as in Carr, Onzere, et al. 2015; Carr, Abrahams, et al. 2015; Carr et al. 2016; Onzere et al. 2017; Carr and Onzere 2018) suggests the following principles for gathering the data necessary to create a rigorous, locally-valid stratification of the population:

- Any population of users, whether a household, community, region, or country, should not be treated as a unified whole, but instead as a collection of individuals containing distinct users of CIS and distinct CIS needs.
- To stratify a user population into meaningful groups that capture as many possible CIS needs as possible, the definition of groups should take place on the basis of reported assemblages of vulnerability, not asset ownership. Reported vulnerabilities, which reflect individual exposure, sensitivity, and adaptive capacity in the face of various shocks and stressors, generally invokes access to critical livelihoods assets. Thus, while this approach does not ignore asset ownership and access, it frames them in locally meaningful ways.
 - Group definitions based on differences in asset ownership/access alone rest on simplistic relationships between wealth, assets, and vulnerability/resilience that overlook the important ways in which social roles and responsibilities shape people's activities, decisions, and outcomes.

- Neither assets nor vulnerabilities should be assumed to have a normal distribution in a given population. Developing indices of asset ownership and vulnerability, and then applying normal distribution functions to index scores, is unlikely to result in a meaningful representation of people’s vulnerability, resilience, or well-being. Without such a representation, it is difficult to rigorously identify CIS needs.
- In nearly all cases, the stratification of the population into groups through assemblages of vulnerability will not capture the full variety of potential CIS users and their needs. Instead, these groups should also be stratified by the social characteristics that shape the roles and responsibilities of individuals vis a vis activities that might be shaped by climate information. While not all questions require the same levels of stratification, and dealing with stratified populations takes scarce time and resources from projects, the failure to accurately assess the appropriate level of stratification is likely to produce challenges for CIS design, implementation, and M&E. In the context of M&E, the impacts of CIS will be uneven across a population, and therefore aggregate measures of uptake, use, and impact will obscure critical differences in the drivers of these outcomes that make the adjustment of existing programs, and the effective learning from completed programs, difficult. To avoid these outcomes, at a minimum we suggest:
 1. Areas where livelihoods are organized around monogamous households are likely to require stratification by gender to understand how gendered roles and responsibilities result in different activities, different vulnerabilities, and different sources of resilience.
 2. Areas where livelihoods are organized into concessions or compounds of multiple households will likely need stratification by gender and seniority, as in this case roles and responsibilities generally emerge not only through one’s gender, but through the intersection of one’s gender with seniority, where more senior individuals have more authority to make decisions.
 3. In areas where multiple ethnicities live in shared communities, investigators should determine if different ethnicities have different roles and responsibilities to decide if this is a relevant social difference. If ethnicity produces significant differences in roles and responsibilities, it should be used as an initial stratification, with #1 or #2 above then applied to capture the likely range of different outcomes, and their causes, among each group.

5.2 Identifying uptake and use

Many CIS projects assume that success is demonstrated through very high rates of information awareness, uptake, and use. However, most climate information is useful for only a subset of a given population. For example, in Zone SN10, men are principally responsible for agricultural decisions around staple grains and groundnuts, while women have little such authority. The delivery of information targeted at such crops will be of use principally to men. Further, if information requires rapid adjustments to one’s crop or variety selections, timing of planting, or timing of harvests, a still smaller subset of the population will have access to the sorts of assets, like animal traction and plows, that enable the use of the information. Therefore, the uptake of this information should not be gauged against 100% of the population, but that proportion of the population with the authority and ability to use that information. In a separate study in Mali, HURDL found that a CIS was only reaching about 15% of the men in the targeted population (Carr and Onzere 2018). However, most of these users were senior men with plows and animal traction, the original intended users of this project. These men had the decision-making authority and equipment necessary to use the

information, and therefore the fact that a large percentage of these men used the advisories and found them helpful suggests that the information was salient, legitimate, and credible.

When we understand the local roles and responsibilities that shape activities and decisions, we are able to define realistic, productive expectations of information uptake and use against which to gauge project performance. Very few types of climate information will ever be useful to 100% of the population, as there are few sources of information that might inform such a wide suite of activities as to inform the disparate decisions of the different users in any household, community, or country. Therefore, understanding what percentage of the population can use the information is critical to assessing how well the information, and the CIS through which it is disseminated, works. More relevant and realistic measures speak about the proportion of a specific user group actually using the information, when people in the group are known to be able to use this information.

5.3 Identifying and measuring impacts

The impact of a given CIS is difficult to assess because climate information has no intrinsic value. Its value lies in the ability of users to employ this information as they make decisions about their participation in activities and use of assets. For example, even the most accurate prediction of the start of an agricultural season is of little use to a poor farmer who does not own a plow or animal traction. That farmer will have to wait until other farmers are willing to lend out their equipment and animals, long after the season has started. Therefore, while differences in activities, crop or variety selections, and livelihoods outcomes might correlate to the presence of a CIS, it is critical to rigorously attribute those differences to the CIS before measuring their value.

This report demonstrates how different datasets derived from different approaches to data collection can work together to provide a rigorous attribution of differences to a CIS. In this case, we used the pathways of change identified through HURDL's qualitative dataset as a starting point for interpretation. By comparing the differences in assets, livelihoods activities, and livelihoods outcomes between those with access to an MWG and those without to these pathways, we were able to identify 1) differences that clearly align with expected pathways of change, and are therefore likely attributable to the CIS and 2) differences that do not align with these pathways. In the latter case, we used the differences identified by ICRAF to interrogate the HURDL data and analysis to identify new, previously-overlooked pathways of change. At the end of this process, we identified a set of differences that appear to be attributable to the MWG, and some differences that are likely the product of a sampling strategy constrained by the implementation cycle of the MWG and influenced by differences in agroecology and market access within the livelihoods zone.

The attribution exercise requires a degree of specificity critical for the evaluation of the impact of the CIS on its stated goals, and on the wider lives and livelihoods of its intended users. As we have demonstrated above, the impacts of a CIS, and the different information it provides, are often specific to particular users in particular places. To both attribute a change to a CIS, and to understand the meaning of that change to the users of that CIS, it is not enough to say that the CIS had an impact on crop selection. Instead, we need to know what crops were selected or deselected and we need to know *who* made changes. The case in this report shows that these sorts of changes are likely to vary by crop, vulnerability group, and other social characteristics of the farmer. For example, we expect to see men stick by some crops, but readily abandon others, because of the social meanings those crops carry. For example, if men are expected to feed the members of their

households with grain from their fields, millet becomes a crop of central importance to men, even if that crop has low market value relative to peanuts or other crops to which they might devote their efforts.

Most CIS have relatively narrow pathways through which they can catalyze change in people's livelihoods. Identifying these pathways and assessing observed patterns of change or difference associated with CIS use against them is a path to the rigorous evaluation of CIS impact that allows for adaptive management to better leverage existing pathways of change, and identify new opportunities for change as they emerge.

5.4 Confidence and confounding factors

ICRAF's sampling, driven by the project implementation cycle, created some uncertainties due to variations in agroecology and market access across this zone. This led to a sample where all of those who were without access to the CIS were located in the driest part of the livelihoods zone, relatively far from major markets, while all of those with access were in a part of the zone with greater rainfall and fairly close to a regional capital. These differences likely impact agroecology and local availability of inputs, which can impact our ability to attribute differences between users and non-users to the climate information. HURDL's data collection also introduces uncertainties that should be characterized. Critically, HURDL gathered its data in two distinct field seasons, one in 2013 and one in 2017. This introduces two types of uncertainty into HURDL's analysis, related to different issues of change over time. The first is a question of whether or not the four-year gap between data collection efforts was enough time that activities and decisions have changed in significant ways that are not accounted for in the data. The second is a concern that Hansen has voiced with regard to the evaluation of CIS (get Jim cites), that CIS likely have different values during different sorts of seasons. For example, during a season of average rainfall, farmers might use the climate information to maximize yields, while in a dry season they might seek to avoid losses. These different goals would present very different appearances of impact, and therefore it is important to characterize the 2013 and 2017 seasons such that we identify any differences large enough to affect the overall structure of decision-making. This, in turn, requires a characterization of HURDL's understanding of decision-making, to identify areas in which it is robust and where it might be susceptible to season-specific events.

LIG is an effort to uncover the decision-making structures that produce observed decisions, actions, and activities. These decision structures do not shift rapidly, because they are comprised of three major parts: discourses of livelihoods (how one lives in a place, including appropriate activities to undertake and how to undertake them), the mobilization of identity (who should undertake those activities and make decisions about how to undertake them), and tools of coercion (locally-legitimate means of compelling individuals to conform to the expectations that emerge from discourses of livelihoods and their mobilization of identity). Agrarian livelihoods are overbuilt for risk and vulnerability, and therefore discourses of livelihoods always incorporate expectations of variability and risk. In a "normal" year (however this might be defined), the memory of previous, challenging years and the likelihood that subsequent years will be challenging is always present. In a challenging year, the memory of and likelihood of a return to normal or favorable years is present. The very questions "what activities should be undertaken?" and "how should they be undertaken?" therefore always incorporate an understanding of and expectation of challenges and opportunities. Variation within historical experience lies within these discourses of livelihoods, not beyond them. Therefore, on a year-to-year basis, these discourses will not shift greatly. In a challenging year, some stressors

may figure more prominently (water scarcity, drought, animal morbidity) than in a normal or favorable year (lack of credit to expand production, lack of access to adequate land), but all of these stressors are ever-present, as both challenging and favorable years are ever-present. For this reason, LIG does not weight stressors listed by agrarian populations, for example by the order in which the stressor is mentioned, because agrarian livelihoods work to address a suite of shocks and stressors whose configuration changes year after year. Because these are unweighted, LIG's framing of the vulnerability context, and the use of assemblages of vulnerability to stratify the population, is unlikely to be significantly affected by year-to-year variation in conditions that fall within the boundaries anticipated by discourses of livelihoods.

The mobilization of identity is also unlikely to change year-to-year. While identity is always situational and intersectional, discourses of livelihoods mobilize particular aspects of identity and shape the roles and responsibilities associated with those identities. What these discourses mobilize, however, goes well beyond the immediate household or community, and beyond the current situation. For example, gender roles can extend throughout broad ethnicities, whether they live in a rural community or a large city, and these roles often have deep historical roots to which individuals feel attachment. These broader identities do not shift rapidly. The mobilization of aspects of these already-durable identities by resilient, durable discourses of livelihoods creates a very resilient set of expectations for how to live in particular places that is not easily displaced.

Finally, this intersection of identity and discourses of livelihoods is maintained through various tools of coercion, sanctions for the failure to conform to expectations that range from verbal corrections and warnings to physical violence and even the expulsion from the household or community. The legitimacy of these tools of coercion are drawn from both wider expectations of identity and the fact that livelihoods, as ways of living in a particular place, provide safety and security in the context of a world marked by variability. When individuals undertake unexpected activities, conduct their activities in ways that are new or otherwise surprising, or refuse to play their roles or live up to their expectations, they put not only themselves, but the wider household, and sometimes the wider community, at risk. In such situations, efforts to encourage individuals to comply with these expectations are seen as legitimate, and will continue to be seen as such until discourses of livelihoods and their mobilization of identity change. Such change does happen, but under normal conditions it does not happen quickly (Carr 2013; Jakimow 2012).

While LIG is robust under conditions that fall within the expectations in discourses of livelihoods, no matter how variable, a LIG analysis can be compromised in conditions of extreme stress or change that depart from expected parameters. For example, under an unprecedented, multi-season drought, the physical risk to life or the associated loss of assets or activities could compromise discourses of livelihoods, calling into question the fundamental assumptions about what activities to conduct, and how to conduct them. This, in turn, can lead to questions about who should be conducting those activities. Without clear expectations to enforce, tools of coercion can lose legitimacy, and the structure of livelihoods decision-making could change substantially. Therefore, any LIG analysis is only valid for the expected spread of conditions under which that analysis was conducted. Any data collection across seasons and years must ensure that no such extremes, and associated potential changes, have taken place in the intervening time.

For the analysis at hand, the LIG analysis remains robust because there was no extreme shift in conditions, either in 2013 or 2017, nor did such an event occur in between. Further, there is no evidence of substantial change in politics, economy, or infrastructure to suggest pressures that might

be more slowly inducing substantial change in the context across the four years between data collections.

5.5 Lessons about synthesizing methods

The experience reported here, though limited, does provide some clear lessons about the nature of the information surveys and ethnographic studies generate, and what might be accomplished by efforts at synthesis. Well-defined surveys provide observations about the conditions in which people live, the resources they have, their capabilities for using those resources, and the choices they make in using them. Suitably designed ethnographic work can attach meaning to such observations, answering questions such as why particular choices are made and how decisions and activities are related. Even with limited resources a survey can have fairly broad reach in a region, covering an expansive territory and engaging many people. Ethnographic studies require more time and resources and, for practical reasons, are much more localized. Assessing the impact of an intervention such as a CIS requires knowledge of both facts and meanings; thus both types of studies are germane and synthesizing them is necessary. However, such synthesis can be sequenced, for example by using qualitative/ethnographic work to establish initial interpretive frameworks which then inform the interpretation of data from ongoing survey collection that seeks to identify patterns of change associated with the CIS.

We have reported here on the steps we took to synthesize information to answer some particular questions and these, we believe, are suggestive of general approaches to combining these different sorts of information. First, the character of the synthesis needed is determined by the questions at hand. This, in turn, can shape the specific character of implementation for different methods under this synthesis. There is no a priori starting point for a synthesis of methods aimed at identifying the impact of a CIS. Instead, the starting point is the impact one expects to measure, and the character of the CIS whose impact is being measured. For example, if one is attempting to measure the impact of a CIS on gender roles among a set of users, it is likely that an ethnographic approach aimed at a relatively small, representative community will provide an effective starting point for data collection, which might then be expanded and tested through survey analysis of a larger population. On the other hand, if one is attempting to measure changes in yield and identify means of scaling up successes, the synthesis might start with surveys that capture differences in yield over space and time, and then use targeted ethnographic work to explain the processes that brought about those yields.

Second, coordinating methods can benefit overall data collection. The nature of this coordination and planning depends on the information one needs to collect. For example, as noted in the example above, preliminary survey work could improve ethnographic planning by helping target the more time-intensive ethnographic work in specific places, or around specific topics. On the other hand, the synthesis above demonstrates that ethnographic results could inform survey design in several ways that would substantially facilitate synthetic efforts. For example, ethnographic work in this livelihoods zone shows that gender is a critical factor in the determination of individual roles and responsibilities, and therefore observed livelihoods decisions. If such data had been available at the outset of ICRAF's work, it could have shaped survey design and implementation to ensure that gender-disaggregated data was available for synthesis.

Third, the greater the degree of coordination between different data collection methods, the more comprehensive the possible synthesis. The studies combined in this report were uncoordinated. For example, HURDL gathered data at a sub-household level, examining the decisions of different members of a household. ICRAF gathered its data at the household level, and at times only for the head of the household. As a result, it was difficult to explain, for example, differences in engagement with animal husbandry across those with and without access to the MWG. Because animal ownership is greatly shaped by gendered livelihoods roles and responsibilities, HURDL's gender-disaggregated data was difficult to map onto ICRAF's data, which was largely gathered through interviews with men. While it was possible to make some adjustments to the HURDL dataset to create greater alignment between the datasets, it is clear that coordination in study design could substantially add to attainable knowledge in this and other arenas.

The uncoordinated character of the syntheses in this report produced challenges from which we can learn, as well. The survey approach taken by ICRAF in Rwanda, while producing a dataset that was robust for its independent purposes (an analysis that crossed livelihoods zones), did not yield enough data within particular livelihoods zones to allow for the rigorous quantitative interpretation of its data such that HURDL and ICRAF could undertake a synthesis similar to that in Senegal. In this case, ICRAF's efforts to achieve an appropriate breadth of study to answer questions about CIS uptake and use did not produce enough livelihoods zone-specific depth to facilitate synthesis, highlighting the challenges around the tradeoff between breadth and depth in monitoring and evaluation, particularly the challenges that will arise as we attempt to synthesize independent, disparate datasets into meaningful assessments of impact.

5.6 Lessons about measuring impact by tracking change

In this report, we have not made any direct observations of change. Instead, we have identified differences in decisions and agricultural/livelihoods between those with access to the MWG and those who lack such access. This presumes that both groups were making similar decisions, and had similar outcomes, before the MWG was implemented, a proposition that we cannot empirically test. Looking ahead, an intervention such as a CIS is intended to effect change, and therefore observations of change over time cannot be completely replaced, even with syntheses such as presented in this report. This is particularly true because in many agrarian settings environmental, economic, political, and social circumstances are changing, and in many cases these changes have little to do with the weather or climate and are therefore uncoupled from the CIS. Therefore, direct observations are of interest.

Having established something of a baseline for decision-making and outcomes in this zone, this report offers an opportunity to construct measurements of change over time. Overall, the structures of decision-making identified by LIG tend to be durable, barring catastrophic shocks that can completely destabilize livelihoods and their attendant social structures. This does not mean that these structures will not change, but that change will generally be slow. As a result, it is reasonable, under conditions outside of a major shock, to expect the results of a LIG analysis to hold for at least five years, and possibly much longer. It is possible to verify the ongoing validity of a LIG analysis through much less intensive targeted investigations. For example, repeated surveys aimed at the different decisions and outcomes laid out in the report above can identify when either decisions or outcomes appear to change, triggering targeted ethnographic investigations into those changes to explain their sources and importance vis a vis the CIS.

6 Lessons about using the livelihoods zone as the scale of design and impact analysis

A central question for CIS in development is the number of people who can be served by a single CIS. As demonstrated by CISRI research into the users and needs of CIS (Carr et al. 2017), effective CIS address clearly defined users and very specific needs. It is impossible to design a CIS for each household or community in a given country. At the same time, assuming that a CIS that works in one part of the country, for one set of users, will be effective in all parts of that country, or for a wide range of potential users, is likely to lead to ineffective CIS. Therefore, the design of effective CIS requires understanding the extent to which findings regarding the potential users of a CIS, and the needs that information will address, scale up.

This synthesis report suggests that the designers of CIS can use the livelihoods zone as their geographic unit of impact. As climate information has no intrinsic value, the impact of climate information services is predicated on their ability to provide, credible, legitimate, and salient information to individuals who can then act on it. Earlier work on CIS design and impact argued that the decisions potentially informed by climate information are very similar across a livelihoods zone, where social structures, livelihoods activities, market access, and agroecology are relatively homogenous. Therefore, it is possible to use highly intensive qualitative approaches, such as LIG, employed in one or two representative communities to develop broadly-applicable understandings of the decision-making among those living in a livelihoods zone, and therefore better identify and interpret the specific actions which produce observed outcomes such as crop selections and agricultural yields.

Under CISRI, we undertook two efforts to test the effectiveness of the livelihoods zone as the scale of CIS design and implementation. In the first, we examined the extent to which independent data supported the idea that qualitative data from a representative community could provide reliable understandings of the decisions that a CIS seeks to influence. In the second, we compared the decision-making seen in two different livelihoods zones in Rwanda to identify notable differences despite broad social similarities among those living in the two zones. This second effort speaks to the need to limit the scaling of a CIS to the livelihoods zone, as outside of a livelihoods zone the decisions a CIS influences change, and therefore the needs for information will change.

6.1 Scaling up to the livelihoods zone: Evidence for validity

In Senegal, HURDL gathered qualitative data from two representative communities in two different parts of a single livelihoods zone. These two communities captured two critical differences: the amount of precipitation with which residents have to work in a given year, and the degree to which the residents enjoy connections to urban markets. HURDL's analysis demonstrated that despite the fact that residents of Panal were in a drier part of the zone with distant links to major markets like Kaolack and Kaffrine, their livelihoods decision-making was very similar to that of the residents of Ngetou Malick, in a wetter part of the zone only 9km away from the regional capital of Kaffrine. This demonstrates that the *structure of livelihoods decision-making* is broadly consistent among sedentary agriculturalists in this zone, regardless of their location. The outcomes of those decisions vary somewhat, from relative rates of investment in animal ownership to specific crop selections, but in all cases observed decisions and outcomes were consistent with a broad structure of decision-making seen in both communities. HURDL's data demonstrates that sedentary agriculturalists in a

livelihoods zone share a structure of livelihoods decision-making, and that one can elucidate that structure through focused work in one or two relatively representative communities in a zone.

Further, in comparing HURDL's qualitative data to that gathered by ICRAF from a large-n household head survey, we were able to provide more evidence for the generalizability of livelihoods decision-making within a livelihoods zone. First, by using HURDL's intensively-derived stratification of the population into three vulnerability groups, we demonstrated that ICRAF's sample stratifies in a similar manner. Second, we demonstrated that the visible outcomes of livelihoods decision-making, as manifest in animal ownership, crop selection, and livelihoods activities, were similar across the two datasets. We argue that this similarity reflects a structure of livelihoods decision-making in the ICRAF dataset that is very similar to that spelled out in the HURDL data.

In summary, we have demonstrated that within Livelihoods Zone SN10, there are a broadly similar set of sedentary agriculturalists who either are, or could be, users of MWG information. If that information is taken up by specific users to inform specific decisions in one part of the zone, we expect that it will inform similar users making the same decisions in other parts of the zone. Therefore, we argue, there is growing evidence that a livelihoods zone provides a useful scale for the reliable design and scaling-up of a CIS. Further, we argue that this evidence suggests it is possible to design impact evaluations of CIS at the scale of the livelihoods zone, employing decision-making structures to identify possible pathways of change across the zone. With these pathways, which can be identified through intensive work in a representative community, it is possible to attribute changes observed in other datasets, such as those gathered through surveys, to the CIS and explain how the CIS produced those changes, while identifying false correlations between the CIS and other changes.

6.2 Limiting CIS to the livelihoods zone: Evidence

While in Senegal we worked in a single livelihoods zone, in Rwanda HURDL worked across two livelihoods zones (Onzere et al. 2019). In each zone, HURDL gathered data on the livelihoods decision-making in a single, representative community. As demonstrated and discussed above, this data speaks to the broad structure of decision-making at play in the livelihoods zone, as opposed to the specific outcomes of those decisions in different parts of the zone. Here, the task is to examine the extent to which livelihoods decision-making is different in these two zones, despite the fact that the populations of these zones share identities and social structures. If there is little or no difference in the structure of livelihoods decision-making across these zones, there is no need to restrict a CIS to a single zone as it will speak to decisions across two or more zones. However, if there are significant differences in the structure of decision-making, a CIS designed in one of these zones is unlikely to be as efficacious in another zone.

This observation is borne out in CISRI's work in Rwanda. As HURDL demonstrated in a separate report (Onzere et al. 2019), despite the similarities in their populations, the decision-making structures in Zones 12 (Eastern Semi-Arid Agro-Pastoral Zone) and 04 (East Congo-Nile Highlands Subsistence Farming) were different in important ways. For example, among those with Stable Income Livelihoods (SIL) in Zone 12 (individuals and households characterized by relatively few concerns for shocks and stressors, large animal ownership, land ownership, the cultivation of a wide variety of crops and perennials, and stable nonfarm income), engagement in business and non-farm employment was viewed as secondary to agriculture and livestock husbandry and members of this

group had low engagement in business activities and formal employment. Because their livelihoods were dependent on agriculture, these respondents' livelihood decision-making was focused on reducing stressors that limit agricultural production, such as drought, crop pests and disease, and long dry season. On the other hand, while agriculture and stressors limiting production remained important aspects of livelihoods among those with SIL in RL04, formal employment and business activities emerged as important strategies in this livelihood zone. As such, constraints related to the intersection of agriculture, and formal employment and business activities were particularly important for SIL respondents in this zone. As a result, for female respondents with SIL in particular, labor constraints were an important consideration in making agricultural decisions. Unlike those in RL12, SIL households in RL04 appeared to limit production by reducing the number of crop varieties grown.

This example shows that while, at first glance, the stratification of populations in these two livelihood zones may appear to produce similar vulnerability groups, the complex embedding of agricultural activity with other livelihood activities, differences in agroecological conditions, as well as varying access to agricultural and labor markets can produce remarkable differences in livelihoods decision-making resulting in significantly varying agricultural orientations and therefore climate information needs. As evidenced in these examples, a scale-up of a CIS oriented towards a diversified agricultural strategy would be optimal for one zone but might miss the needs of users in another zone.

Thus, HURDL's data from Rwanda supports earlier evidence from Mali (Carr et al. 2016; Carr, Onzere, et al. 2015) which suggests that livelihoods decision-making can differ significantly across livelihoods zones. Sometimes these differences are a product of the different populations and social structures in each zone, the different agroecologies of the zones, the different market access of each zone, or some combination of the three. In Mali, the same CIS had different rates of uptake and use across four livelihoods zones in the southern part of the country, despite broad similarities in social structure and the organization of agrarian life in the populations of these zones. Instead, agroecological differences in each zone drove different decision-making around agriculture, which in turn made the weather and climate information more or less valuable, depending on what zone the farmer lived in. This evidence strongly suggests that scaling a CIS beyond a livelihoods zone without considerable investigation into the new users and decisions that CIS is meant to inform would, at the very least, limit our ability to effectively measure its impact. The pathways of change observed in one livelihoods zone are unlikely to be the same in another, and therefore the attribution of observed changes to a CIS in livelihoods zones outside those for which the CIS was designed are likely to be difficult and much less rigorous. Instead, meaningful impact evaluations of CIS are livelihoods zone-specific. In the worst of cases the use of users and decisions from one zone to inform the design of a CIS in another could limit the potential impact of that CIS in new locations, as the CIS might target vulnerabilities that do not apply to decision-making in the new zone.

6.3 Summary: Scaling CIS to the Livelihoods Zone

The evidence from CISRI, like that from other projects, strongly suggests that the livelihoods zone is the optimal scale for the design of a CIS. Within a livelihoods zone, the decision-making structures, available activities, available resources, and local environment are similar enough to allow for the reliable identification of users and needs, and the meaningful measurement of CIS impact. Scaling beyond a livelihoods zone invokes new users, decision-making, resources, and environments such that the original CIS and the information it delivers are unlikely to meet the specific needs of

those in the new livelihoods zone. Just as CIS design needs to adapt to specific livelihoods zones, so too does CIS evaluation. The rigorous attribution of observed changes in livelihoods and well-being to a CIS in one zone are unlikely to rigorously apply to those seen in another zone, and therefore meaningful evaluation of CIS will be livelihoods zone-specific.

7 Conclusion: Elements of a working framework for synthesizing survey studies with in-depth qualitative studies

The efforts summarized in this report represent a key aspect of the CISRI Learning Agenda (Carr et al 2017), specifically item 2.1, assessing differences in information obtained by different methods, and identifying ways of integrating information from different approaches, shown in Figure 7.1 below. Our experience demonstrates that efforts to synthesize observations and findings from broad surveys with in-depth qualitative village studies are both feasible and worthwhile; they create opportunities for learning that would not be achievable by either sort of study on its own. Our report contributes to this development of the learning agenda, and therefore the practice of designing, implementing, and monitoring and evaluating climate information services, in three ways. First, we present observations and findings from our synthesis effort relevant to all three aspects of CIS programming. Second, the steps we took to achieve a synthesis of the two types of studies offer a practical template for combining other qualitative and quantitative studies to facilitate similar advances in CIS design, implementation, and M&E. Finally, drawing on our experience in this report, we offer some observations about opportunities for strengthening syntheses through planning and coordination, and about two aspects of the learning agenda that are best pursued through combined studies.

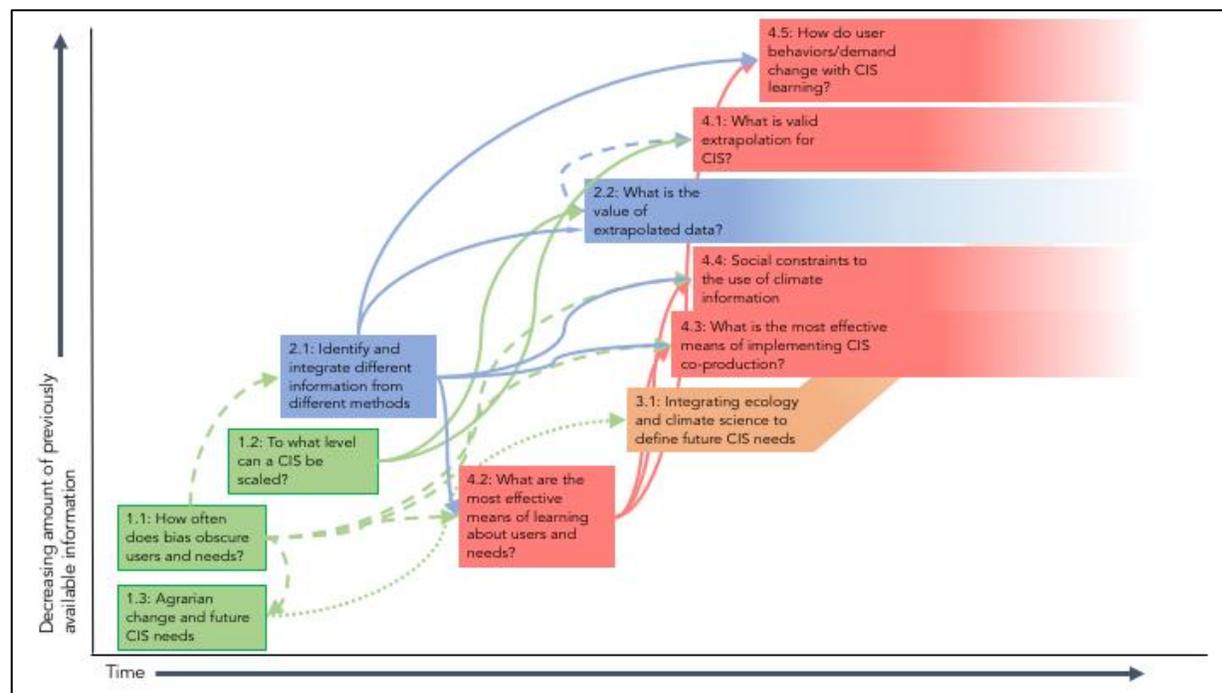


Figure 7.1: The learning agenda from Carr, et al 2017, illustrating the importance of item 2.1 to the rest of the agenda

7.1 Key observations and findings

7.1.1 Identification of vulnerability subgroups

As described in section 4.1, we were able to distinguish characteristic subgroups among village farmers related to their reported vulnerabilities. Our work shows that within a village there are different vulnerability groups, each marked by distinct shared concerns and needs. These concerns and needs have different relationships to climate information; some can be addressed directly through the provision of accurate, timely information, while others have no direct connection to weather or climate. As a result, the provision of weather and climate information will have uneven benefits across groups, and therefore uneven impacts across a population.

This broad finding about the different needs for weather and climate information within a population speak to two parts of the learning agenda. First, this study informs item 1.2 in Figure 7.1, which asks to what level, and over what social groupings, a particular CIS can be scaled. While there was a degree of relationship between the vulnerabilities of a given group and their asset ownership, assets were at best a partial proxy for the needs and concerns of these groups. Therefore, the effective scaling of a climate information service across a broad population will require identifying distinct users and needs in the population, information that is best obtained through detailed qualitative investigation of reported vulnerabilities and concerns.

Second, this study also speaks in part to item 1.1 in Figure 7.1, “how often does bias obscure important information about users and their needs?” With regard to CIS, bias can take a variety of forms and enter through various pathways. A common form of bias is assuming that because an entire population shares an exposure to one or more stresses, they share vulnerability to that stress. This assumption has the effect of lumping disparate populations together, making distinct needs difficult to identify within that population, and therefore obscuring the ways in which a CIS might reduce vulnerability or create other livelihoods opportunities. As we discuss in section 4.1.5, another form of bias proceeds from the assumption that the identification of relative vulnerability, and therefore the division of the population into groups by shared vulnerability, can be accomplished through the use of unexamined statistical distributions of asset ownership. Such efforts are likely to misidentify the distribution of vulnerability in a population, and lump individuals with disparate concerns and needs into the same group, obscuring the specific needs for weather and climate information that might exist in the population. Once again, this makes it difficult to identify the different pathways of impact for a CIS in a given population, which makes the meaningful monitoring and evaluation of CIS performance very difficult.

These contributions have direct implications for the monitoring and evaluation of CIS. Specifically, they demonstrate that monitoring and evaluation efforts must take into account the different needs for CIS within a population, identify those needs, and from that effort develop group-specific expectations of CIS impact. Assuming that a CIS can and should have similar impacts across an entire population does not reflect the reality of rural livelihoods, especially the need for and capacity to use weather and climate information. CIS M&E that does not account for these different needs and capacities is unlikely to accurately represent the impacts of CIS on either the behaviors or material conditions of life of users.

7.1.2 Observation of decision-structures

One reason for in-depth learning about people's concerns and vulnerabilities is that these are important to how people conduct their lives and thus to how they might use climate information. Specific to each subgroup we identified decision structures that explained observed use or non-use of climate information. Knowledge about such decision structures should inform the tailoring of climate information to various subgroups.

These decision structures present an opportunity to calibrate monitoring and evaluation efforts to the likely magnitude of impact of a given CIS. For example, as demonstrated in Senegal, women are not viewed as legitimate producers of millet, and therefore they are discouraged from cultivating it. Therefore, expecting a CIS to contribute to increases in women's millet cultivation, which is constrained not by information but by social expectations, is unrealistic and should not be seen as a failure of the CIS. On the other hand, men are responsible for millet cultivation as a means of feeding their families, so if this same information has no effect on men's millet cultivation practices or outcomes there likely is a problem with the CIS that should be explained and addressed. Similarly, given the analysis in Senegal, an effective CIS should drive increases in the rate of maize cultivation. However, it will not have a large effect among those with SPL, who are already producing maize. Instead, by reducing the risk around such cultivation, it will allow those with SSL and LRL to diversify into this precipitation-sensitive crop, with increases most pronounced among those with LRL.

7.1.3 Vulnerability groupings and decision-structures appear to hold across a livelihood zone

Returning to item 1.2 in Figure 7.1, which also addresses the spatial region to which a particular CIS be scaled, we observed in sections 4.1 and 6 that vulnerability groupings and their associated decision structures appear valid across a substantial geographical area, namely that of a FEWS-NET-defined livelihood zone. While this finding is not surprising given the close relationship between people's modes of living and their vulnerabilities, this empirical finding is important. It suggests that scaling CIS over geographical regions the size of livelihood zones is feasible and provides guidance for how to do that.

For the purposes of monitoring and evaluation, this finding suggests that detailed, qualitative M&E efforts do not have to be undertaken in a large number of communities to establish valid understandings of vulnerability groupings and livelihoods decision-making. Instead, the targeted use of qualitative methods in a small number of representative sites can provide the detailed information needed to calibrate M&E expectations, and to meaningfully interpret impacts from large-scale survey data gathered as part of M&E efforts.

7.1.4 Different livelihood zones appear to have different vulnerability groupings with different decision-structures

The finding that different livelihood zones have different vulnerability groupings and different decision structures, the inverse of that from section 7.1.3, suggests that livelihood zone boundaries delineate the approximate boundary where we would expect these relationships to change significantly. Those differences should influence the design of CIS appropriate to different regions.

For monitoring and evaluation efforts, this finding suggests that while qualitative work to identify vulnerability groupings and livelihoods decision-making may not require extensive sampling within a livelihoods zone, such sampling and identification should take place in each livelihoods zone covered by a CIS. The application of vulnerability groupings and livelihoods decision-making from one livelihoods zone to another is not likely to accurately represent the pathways through which a CIS might have impact in another livelihoods zone.

7.1.5 Observing and interpreting changes over time is an unfilled gap in our synthesis

We also identified a critical unfilled gap in our joint effort: we lacked sufficient information to adequately observe change over time and to assess likelihoods of potential future change. This gap was identified as a key future need, item 4.5, in the Figure 7.1 depiction of the learning agenda (Carr et al 2017). As described in section 4.3, we have observed clear behavioral differences between those with access to and using the MWG and those lacking access and not using the MWG in Senegal, and our qualitative research provides attribution of the differences to the access and use of the MWG. However, in the absence of longitudinal data, we have no measure of the durability of the observed changes nor, as we discuss in section 5.5, can we assess the nature of any material change resulting from behavioral differences.

This finding has an important implication for monitoring and evaluation. While behavioral impacts may emerge quickly in the context of a CIS, these impacts take time to result in materially-measurable impacts. If M&E only focuses on material outcomes, it is likely to overlook these behavioral changes. As a result, it will be impossible to learn about the relationship between behavioral impacts and longer-term material impacts. It will also be impossible to learn about the emergence and durability of behavioral impacts.

7.2 A template for synthesis when there has been little coordinated planning of data collection

There was only limited coordination between the broad survey efforts and the in-depth LIG studies synthesized in this report. That situation is likely to hold for many other studies, as research funding for M&E outside of existing projects will be limited (Carr et al 2017). As discussed in section 5.5, the series of steps we performed shows that a synthesis combining results from the disparate studies is feasible under some circumstances; it also provides a template for future efforts at combining such studies. We list the steps below:

7.2.1 Test how similar the sampled populations are in the different studies

A prerequisite for synthesis is that the populations studied be sufficiently similar so that findings from each study can be carried over to the other studies. So testing for similarity in population aspects deemed significant (as described in section 4.1) must be the first step. Our synthesis in this report shows that testing for similarity is feasible with uncoordinated data collection.

7.2.2 Identify surrogate measures that substantially capture the disaggregation into vulnerability groups performed in a detailed qualitative analysis

An in-depth study such as LIG will enable the disaggregation of a village sample into groups characterized by their concerns and vulnerabilities and by what assets they have or lack related to those concerns and vulnerabilities. Further interview information will establish the character of decision-making for the population at large, which is then translated into specific decisions depending on the specific situation of those in each vulnerability group identified. Though less

detailed, broader surveys will capture significant information about household characteristics and assets. These two datasets can be disaggregated in similar manners by employing proxies, for example in terms of household characteristics and asset ownership associated with LIG-classified vulnerability groups, to define a surrogate classification of the broader sample. An example is the classification we created in Box 1 of section 4.1.3.

7.2.3 The in-depth analysis can be used to interpret and provide explanations for differences between users and non-users of climate information services

Characteristics of users and non-users of climate information services should now be identified separately for each of the (surrogate) vulnerability groups in the broader survey sample. These differences should be compared and interpreted according to the decision-making structures previously identified through qualitative analysis. This will allow for the identification of causal explanations for observed differences between users and non-users within each vulnerability group, as exemplified in section 4.2.

7.3 A template for synthesis when there has been the opportunity for coordinated planning

While much can be achieved even without careful preliminary planning, as we discuss in section 5.5 it is clear that coordinated efforts could accomplish significantly more. Four aspects of coordinated planning across data collection methods offer significant opportunities for stronger findings.

7.3.1 Coordination in the choice of sampling questions and in the selection of people to sample will make comparisons significantly stronger

Choosing who to ask questions of, what to ask, the context in which to ask particular questions, and how to phrase the questions, all present serious challenges for any study. Unexpected ambiguities and biased or missed perspectives are always likely. These problems may become more acute when different studies make these choices independently; conversely, a thoughtful coordination of such choices can enable studies to reinforce each other and reduce ambiguities and bias. In the case of the pilot work in this report, our findings would have been more robust had the two teams coordinated sampling to ensure that survey data was always gathered from multiple members of the same household to capture intra-household differences and dynamics.

7.3.2 Sequencing of studies offers further possibilities for improvement

The most useful approaches to coordination enable studies of different types to inform each other. So, for instance, the design of a broad survey would be usefully informed by an initial in-depth study, and the findings of the survey could well suggest a further in-depth exploration of particular topics. An alternative sequencing would be to begin with a limited overview survey that would inform in-depth work. And that could be followed by a more targeted survey. The specific goals of the monitoring and evaluation program (i.e. what is to be learned, who needs to learn, etc.) will shape this sequencing.

7.3.3 Coverage of livelihood zones

Because livelihood zones appear to set a useful spatial scale for learning about CIS uptake and use, coordination would be worthwhile to assure that the range and variety of individuals within a livelihood study receive attention in both kinds of study. Boundaries of livelihood zones might merit particular attention as well.

7.3.4 Investigate possibilities for acquiring longer-term longitudinal information

Planning and coordination could be particularly helpful in securing the kind of long-term longitudinal data that has so far been lacking. There could be further possibilities for coordination of sample questions and people to ask and for sequencing different types of studies.

7.4 Livelihood zones appear to be a useful scale for the design and monitoring and evaluation of CIS, but this needs further elaboration and testing

This pilot synthesis provides evidence to support the idea that HURDL's vulnerability group stratification and associated decision structures hold across FEWS-NET's livelihood zone 10 in Senegal. This is a significant finding that suggests the spatial scale for which we can expect valid generalization about users and their needs. Work in Rwanda further suggests that the livelihoods zone provides something of a limit to valid generalization. The use of the livelihoods zone as a scale of CIS design and monitoring and evaluation requires further testing to establish its validity in a wider range of contexts. Further work examining this hypothesis should seek to identify key variables that influence the generalizability of ethnographic findings, as controlling for variables that limit generalizability might allow for the discernment of general lessons about CIS uptake, use, and impact.

7.5 Characterizing uncertainty and making findings useful for policy

A framework for synthesizing different types of data into a coherent monitoring and evaluation effort requires characterizing the uncertainty in each dataset, as well as the uncertainties that arise when these datasets are combined. At times, the synthesis of datasets can ameliorate uncertainty in one or both, raising confidence in the findings. However, there are also likely to be situations where the uncertainty in these datasets is compounded through the synthesis process, lowering confidence in findings. To address uncertainty, we suggest consideration of the following sources of uncertainty and the factors that can lead to their importance or unimportance:

7.5.1 Fast and slow variables

Efforts to understand the decision-making of users, which shapes their need for and ability to use weather and climate information, identifies and characterizes different aspects of decision-making that change at different rates. It is important to identify those variables that change slowly, which will not be greatly impacted by small differences in the sampling timeframe across methods, versus those that change quickly and could display significant differences in very short timeframes, thus impacting efforts at synthesis.

HURDL's experience with LIG suggests that the major variables of decision-making, which include discourses of livelihoods, the mobilization of identity by those discourses, and locally-legitimate tools of coercion, are slow-changing variables that will not shift much in a few months or a season. Thus, the underlying structure of decision-making are likely slow variables, and the collection of data around this structure is not highly time-sensitive, and under normal conditions will likely remain valid for the three- to five-year timeframe of most development projects.

On the other hand, weather and climate can be highly variable within a season and across seasons, as can market conditions. These fast-moving variables present the conditions that individuals employ

their decision structures to address. Therefore, while decision structures might change slowly, the outcomes of those decisions can vary within a season, and across seasons. These outcomes are very sensitive to time, and a lack of temporal alignment in data collection related to these outcomes can increase the uncertainty associated with synthesis.

7.5.2 Timeframe

Because observed decisions to take up CIS are shaped by different variables which can change at different speeds, efforts at synthesis must appropriately characterize any gaps in time between collection of different datasets. While the absolute difference in time (i.e. measured in days, weeks, or months) is important to identify, more important is the difference relative to the decisions and outcomes in question. For example, if data are collected four months apart, but in the same agricultural season, this is less problematic than data collected four months apart, but in two distinct agricultural seasons with different cropping cycles and goals.

7.5.3 Changing conditions

The assessment of fast and slow variables, and the meaningful differences in the timing of data collection, rest on an assumption of conditions among the users that, if not very stable, have not departed historical or otherwise expected conditions such as to induce extreme stress and the abandonment of prior decision-making. While such stresses are likely to be highly visible events, such as multi-seasonal drought or armed conflict, an assessment of the overall stability of conditions and decision-making is critical to ensure that data collected in one part of a synthetic effort is meaningfully related to data collected in another. Further, understanding the character and magnitude of change in a given user population is critical for assessing the future validity of any findings of M&E. The efforts outlined in this report assume relative continuity of existing decision structures (which includes incremental change). Should Zone SN10 undergo a multi-year drought, or the outbreak of substantial conflict, we should not assume such continuity, and would have to evaluate that assumption before continuing with any monitoring and evaluation efforts.

7.6 Summary

There is much to be gained from the synthesis of different approaches to the monitoring and evaluation of CIS. While such synthesis is greatly enhanced by the coordination of different data collection efforts, we can accomplish a great deal by taking advantage of opportunities to synthesize different forms of data as they arise, even when those datasets are not fully aligned in time or in the data collected. Thus, there is great potential to work with and build on the M&E efforts associated with existing CIS to further our understandings of what drives the uptake and use of weather and climate data, the barriers to such use, and various means of addressing those barriers while enhancing opportunities for uptake. At the same time, such efforts can further our efforts to learn from longitudinal study, as the function of a CIS operating in a variable climate can only be fully discerned through the consideration of its performance, and its use, under a range of different conditions.

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