TECHNICAL REPORT

# ASSESSING MALI'S *DIRECTION NATIONALE DE LA MÉTÉOROLOGIE* AGROMETEOROLOGICAL ADVISORY PROGRAM

## PRELIMINARY REPORT ON THE CLIMATE SCIENCE AND FARMER USE OF ADVISORIES

**MAY 2014**
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Engility Corporation Contact:
Glen Anderson, Chief of Party, Glen.Anderson@EngilityCorp.com
Engility Corporation
1211 Connecticut Ave., NW
Suite 700
Washington, DC 20036

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Prepared by:

Engility Corporation

Washington, DC

*and*

**Editor:**

Edward R. Carr

Humanitarian Response and Development Lab

Department of Geography

University of South Carolina

Columbia, SC

**Contributing Authors:**

Edward R. Carr, University of South Carolina, USA

Tufa Dinku, International Research Institute for Climate and Society, Columbia University, USA

Alessandra Giannini, International Research Institute for Climate and Society, Columbia University, USA

John Kupfer, University of South Carolina, USA

Simon Mason, International Research Institute for Climate and Society, Columbia University, USA

Abdoulaye Moussa, ICRISAT

**Contributing Researchers:**

Anthony Berenguel, Stratus Consulting, Boulder, CO, USA

Nathan Braun, Stratus Consulting, Boulder, CO, USA

Michael Duckworth, Stratus Consulting, Boulder, CO, USA

Fiona Gavin, Stratus Consulting, Boulder, CO, USA

Thomas Hodgson, Stratus Consulting, Boulder, CO, USA

Tshibangu Kalala, University of South Carolina, USA

Kwame Owusu-Daaku, University of South Carolina, USA

Pierre C. Sibiry Traore, International Crops Research Institute for the Semi-Arid Tropics, Mali

Joel Smith, Stratus Consulting, Boulder, CO, USA

Justin Stein, Stratus Consulting, Boulder, CO, USA

Lassana Toure, Institut d'Economie Rural, Mali

Kalifa Traore, Institut d'Economie Rural, Mali

Carolyn Wagner, Stratus Consulting, Boulder, CO, USA

Contact: Michael Cote, Engility Corporation, Michael.Cote@EngilityCorp.com

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# ACRONYMS

| | |
|---|---|
| AET | Actual Evapotranspiration |
| AGRYHYMET | *Centre Régionale de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle* (Regional Centre for Training and Application in Agrometeorology and Hydrology) |
| ACMAD | African Centre of Meteorological Applications for Development |
| ASECNA | Agency for Safety and Aerial Navigation in Africa |
| CCAFS | Climate Change, Agriculture and Food Security Theme of the Consultative Group on International Agricultural Research |
| CGIAR | Consultative Group on International Agricultural Research |
| CMDT | *Compagnie Malienne du Développement des Textiles* (Malian Cotton Development Company) |
| CILSS | *Comité permanent inter-État de lutte contre la sécheresse au Sahel* (Permanent Inter-State Committee for Drought Control in the Sahel) |
| CPT | Climate Predictability Tool |
| DNA | *Direction Nationale de l'Agriculture* (National Agricultural Directorate - Mali) |
| DNE | *Direction Nationale de l'Elevage* (Livestock National Directorate - Mali) |
| DNEF | *Direction Nationale des Eaux et Forêts* (National Water and Forestry Directorate - Mali) |
| DN | National Internal Affairs Directorate (Mali) |
| DNM | *Direction Nationale de la Météorologie* (National Meteorological Directorate - Meteo Mali) |
| ETP | *Equipe de Travail pluridisciplinaire* (Pluridisciplinary working group) |
| ECMWF | European Centre for Medium-Range Weather Forecasts |
| FEWS-NET | Famine Early Warning System Network |
| FDP | Forecast Demonstration Project |
| GLAM | *Groupes Locaux d'Assistance Météorologique* (Local Meteorological Support Groups) |
| GTP | *Groupe de Travail Pluridisciplinaire* (Multidisciplinary Working Group) |
| GTPA | *Groupe de Travail Pluridisciplinaire d'Assistance Agrométéorologique* (Multidisciplinary Working Group for Agrometeorological Assistance) |
| GPC | Global Producing Centres |
| GPCC | Global Precipitation Climatology Centre |
| GCOS | Global Climate Observing System |
| ICRISAT | International Crops Research Institute for Semi-Arid Tropics |
| IER | *l'Institut d'Economie Rurale* (Institute of Rural Economy - Mali) |

| | |
|---|---|
| IRI | International Research Institute for Climate and Society |
| MET | Maximum Crop Evapotranspiration |
| NGO | Non- Governmental Organization |
| NMHS | National Meteorological Hydrological Services |
| NOAA | National Oceanic and Atmospheric Administration |
| OHVN | *Office de la Haute Vallée du Niger* (Office of the High Niger Valley - Mali) |
| OMA | Agricultural markets observatory |
| ORTM | *Office de la Radiodiffusion Télévision du Mali (*National Radio and Television – Mali) |
| PET | Potential Evapo-Transpiration |
| PRESAO | *Prévisions Saisonnières En Afrique de l'Ouest* (West Africa Seasonal Forecast) |
| PV | Crop protection service |
| SDC | Swiss Agency for Development and Cooperation |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environment Program |
| USAID | U.S. Agency for International Development |
| USAID ARCC | U.S. Agency for International Development The African and Latin American Resilience to Climate Change Program |
| WCP | World Climate Research Program |
| WMO | World Meteorological Organization |

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# EXECUTIVE SUMMARY

## BACKGROUND

In June 2011, USAID organized a West African Adaptation Workshop under the Adaptation Partnership in Dakar, Senegal. The workshop had several goals, including improving the awareness of and demand for climate services in the region among decision-makers in various sectors, improving climate service providers' understanding of decision-makers' needs, identifying opportunities to design and deliver climate services for decision making, and sharing information on good practices and models. At that meeting, representatives of Mali's Direction Nationale de la Météorologie (National Meteorological Directorate, henceforth Meteo Mali) gave a presentation about their ongoing Programme d'assistance agro-météorologique au monde rural (agrometeorological assistance program for the rural world). The results they reported were remarkable, with reported yield increases of 20-60%, depending on the part of the country in which the information was used. Impressed by what they had seen, participants from several Sahelian countries expressed interest in starting similar programs. To facilitate this process, USAID commissioned this assessment of Meteo Mali's agrometeorological program.

This assessment has several related goals. First, it aims to independently evaluate the impact of the agrometeorological program on agricultural outcomes in Mali, providing necessary credibility to justify the transfer of similar programs to new countries. Second, through its evaluation of program operation, function, and outcomes, the assessment seeks to provide a set of criteria that can inform the programming, design, and implementation of climate services for farmers in the Global South. Finally, the assessment contributes to a small, but growing body of knowledge on the workings and efficacy of climate services for smallholder farmers in sub-Saharan Africa, and the Global South more broadly. USAID committed itself to doing a deep, evidence based-analysis of the function and impact of the Mali Agrometeorological program to inform the design and evaluation of other climate services programs in its development portfolio and demonstrate leadership in this field.

This report is the first of two that will comprise the full assessment. This report contains an assessment of the forecasts and science behind the advisories themselves, and an assessment of the use of the agrometeorological advisories at the community, household, and individual level in southern Mali. Because the social dynamics shaping the use of climate information in agriculture and livelihoods more broadly are complex, a full appraisal of the working and impact of the program for farmers will require additional qualitative fieldwork, the results of which will be covered in a second report. This report also contains recommendations for activities and actions that might enhance the working of Meteo Mali's program now, and identifies future research needed to develop a fuller understanding of the use of advisories by farmers, both for use in the Mali program, and to define criteria that can inform the programming, design, and implementation of climate services for farmers in the Global South. For example, the report recommends:

- Performing a detailed quantitative assessment of the past performance of the forecasts that undergird the advisories
- Shift current advisory construction away from the use of analogue years, as previous experiences of similar rainfall may not hold in a changing climate
- Conduct research into the predictability of intra-seasonal variations in rainfall, including the start and end dates of the rainy season, and probability of extreme events, such as prolonged dry spells or very intense rains, at both one-week and one-month lead times, as parallel studies in other parts of the Sahel suggest these quantities are potentially predictable

- Investigate means of conveying forecast uncertainties to farmers as a part of advisories
- Expand advisories to address gender, the needs of pastoralists, and for poorer farmers who may have greater difficulty responding to advisories in a timely manner
- Better understanding the role of weather and climate (and therefore climate services) in rural livelihoods more broadly

## PROGRAM BACKGROUND AND FUNCTION

Mali's agrometeorological advisory program was established as an emergency measure to address food insecurity linked to droughts in the late 1970s and early 1980s. Focused on five common crops-millet, sorghum, peanuts, cotton, and maize-the program's broad aim was to assist rural farmers in making informed agricultural decisions to improve production and alleviate drought-related food insecurity. As part of the project, farmers were given rain gauges to measure rainfall in their fields, and were trained in taking measurements and using them in conjunction with advisories from Meteo Mali to determine appropriate planting dates and variety selections in different parts of the country. Practically speaking, at the outset of the planting season, a farmer could decide when to begin planting and what cycle length variety to plant based on the advisories combined with local rain gauge readings. Farmers with rain gauges provided rainfall information back to Meteo Mali, who convened a multidisciplinary working group (originally the *Groupe de Travail Pluridisciplinaire* or GTP, later merged with other working groups to form the *Groupe de Travail Pluridisciplinaire d'Assistance Agrométéorologique* or GTPA) that included representatives of from several government agricultural service agencies. During the GTP's fortnightly meetings, agro-meteorological opinions, warnings and advice were formulated, partially based on rainfall information from reporting farmers, and then circulated to communities through national radio and television. The GTP's/GTPA's role as a boundary institution for "translating" climate data into practical advice for farmers is an important element of the program.

As the program evolved, the GTPA also gathered feedback from participating farmers, and in response the program has evolved to deliver a wide range of information to farmers from short-term weather forecasts to current phytosanitary conditions to targeted, actionable agrometeorological advice. It became very popular among farmers and the Malian government, and was institutionalized within the Malian government such that when donor funding ended in 2005, the program had a budget that allowed it to continue.

Because Mali's Agrometeorological Advisory program was established as an emergency program, it was never designed for rigorous monitoring and evaluation, and its working and impact were largely undocumented. These facts have made the post hoc assessment of the function and impact of this program very challenging. Future climate services programs must build in this documentation and analysis at the outset to facilitate learning, evaluation, and the evidence-based adjustment of program activities to maximize impact. This report demonstrates what sorts of analysis are relevant, and what sorts of information must be collected to enable that analysis.

## MAIN FINDINGS

This assessment found that current rates of use by farmers of agrometeorological advisories were generally very low (in most participating villages surveyed use rates were less than 20%). Further, in nearly all parts of southern Mali women's rate of use of the advisories was lower than that of men, and often there was no participation in the program by women. The reasons for these patterns are many, and appear to be related to farmers' ability to use the advisories, rather than their trust in the advisories' guidance. For example, the advisories do not target the crops women grow, limiting the utility of the information and their participation in the program. The low rates of participation among men are likely closely linked to wealth and assets, where those with more wealth and assets are more able to respond to advisories with regard to variety selection and the timing of agricultural activities, such as planting. Further, some decisions about variety selection are about timing markets, for example to bring in harvests during peak prices, as opposed to climate considerations. It is critical to note, however, that the evidence from this assessment suggests that farmers using the advisories followed them closely with regard to variety selection and timing of planting (two closely related activities). This suggests that, for those farmers able to use them, the advisories are seen as credible and useful.

The advisories, as currently delivered, appear to assume that the end users (farmers) are unable to work with uncertainty. Advisories for each crop currently suggest that farmers plant a crop variety of a single cycle length that is tied to the most probable seasonal outcome (length and total precipitation). However, these forecasts are probabilistic, and often the most probable outcome is only 60% likely, with significant likelihood of deviations to longer or shorter seasons, or more or less precipitation. By communicating this inherently uncertain information with a tone of certainty, the advisories could, under some circumstances, increase the risk of inadequate harvests or crop failure by advocating for the cultivation of inappropriate varieties. Farmers in Mali (and much of the Global South) understand uncertainty and address it every day in their livelihoods decisions. Adding some sense of the uncertainty in these advisories would allow farmers to build this into their overall risk calculus. Further, risk mitigation measures, such as index insurance, can help guard against negative outcomes when advisories are incorrect. Such interventions will allow farmers to take bigger risks so that they can capitalize on the advisories in good years, while having a safety net to cover those years in which advisories are (inevitably) incorrect.

With regards to the forecasting methodologies used, this assessment found a need to better assess past performance to verify and improve the methodologies employed. Meteo Mali's current seasonal forecast methodologies date back to the establishment of PRESAO, the regional climate outlook forum for West Africa, which has been convening yearly since the 1997–98 El Niño event. There is a need to verify these methodologies quantitatively, and to assess their scientific basis in the face of the emergence of trends in extreme precipitation behavior, such as drought and flooding, that may be attributable to anthropogenic influence. As such, these trends cannot be predicted based on past experience, and require a dynamical synthesis of our understanding of the West African climate system in the context of climate change.

## CLIMATE SERVICES DESIGN RECOMMENDATIONS

This preliminary assessment of the Agrometeorological Advisory Program points to several general principals that should inform interventions in this program, and the design of future climate services programs:

- **Reliable climate data provides the foundation for any climate service.** There is no climate service without climate data. Thus, strengthening climate services needs to start with strengthening the capacity of service providers to collect, process, and disseminate climate data and information. However, one also needs to make sure that existing, available climate data is being used effectively before collecting or incorporating new data into services.

- **The design and delivery of effective climate services rests on a foundation of rigorous science and technology for forecasting, but requires substantial attention to social considerations that shape the salience and credibility.** Forecasts that lack appropriate rigor and skill can be worse than no forecast at all. Climate services cannot be effective without fundamental investments in meteorological service equipment, capacity, and historical data. At the same time, it is impossible to translate even the most rigorous, accurate forecast into actionable information without attention to issues of who can act on that information and why. The assumption that agrometeorological forecasts and other information are broadly actionable and of the same utility to all potential users is clearly refuted by the evidence in this report. This report points out gaps and opportunities on both fronts: project and program designs must dig deeper into what climate information users need and why, but efforts to address these needs must also be tempered by scientific and technological constraints that shape the quality of the available information.

- **Whether users find the information delivered by climate services useful and actionable depends on how that information aligns with the decisions they make.** The decision-making behind observed rural livelihoods activities and outcomes is complex and often locally-specific, incorporating economic, environmental, historical, social, and political considerations. As this report demonstrates, the information provided by program advisories addresses a relatively small subset of the decisions the rural Malian population makes in their efforts to address both the challenges and opportunities they encounter in their everyday lives. For example, while advisories address the needs of rain-fed agriculturalists, there are many activities that are not addressed by advisories, such as hand-irrigated gardening and animal husbandry. These activities are very often part of a household's livelihood strategy and can serve as a hedge against climate variability. For example, households can address insufficient rainfall for staple crop production by selling livestock and garden products to buy grain. At the same time, farmers are also working within these challenges and constraints to maximize returns, for example, by planting short-cycle varieties to ensure a harvest at the peak of the hungry season, when prices are highest. Increasing understanding of livelihood decision-making and associated activities increases the ability of development actors to identify and deliver climate services information that it makes the most sense and the most difference.

- **Some users are more likely to benefit from climate services than others.** This report suggests that a farmer's access to wealth and assets shapes his or her ability to act on advisories. For example, poorer households often have less control over the timing of planting and weeding than wealthier households, as they are forced to wait for the wealthy to lend/rent them farm equipment and often need to work on the farms of richer households early in the season to earn money. As a result, they cannot respond to advisories in a timely manner, and often plant late in the season when they must plant short-cycle varieties and meaning that advisory recommendations are no longer relevant. Therefore, we cannot assume that climate services will inherently bring broad-based benefits to the target population. This is an important consideration, as future climate services programs may be designed with a poverty reduction goal. If climate services are to benefit poorer populations with fewer assets and aid resilience and extreme poverty agendas in places like the Sahel, it is important to analyze the capability of these populations to be able to use and benefit from this information.

- **The wide disparities between men and women's use of the advisories points to the importance of both understanding livelihoods activities and decisions *and* enabling the environment for climate services use.** There appear to be many reasons why women are not using the agrometeorological advisories, all related to social issues and gender roles. In the communities surveyed, men control the production of the rain-fed crops covered by the agrometeorological advisories. So, even if women have access to the information, they have little ability to act on it. The crops that women primarily grow, especially garden crops, are not covered by the advisories. Additionally, men in charge of village rain gauges are not sharing information with women in their communities. Not considering these gender issues in the design and delivery of climate services in Mali will leave out or only indirectly benefit roughly half of the population, an issue that should be better understood and, where possible, addressed to expand the beneficiary population and improve program impact. In short, if women are to benefit from climate services programs in Mali and beyond, their specific activities and decisions must be considered and built in from the outset.

# 1. INTRODUCTION

*EDWARD R. CARR, UNIVERSITY OF SOUTH CAROLINA*

For many subsistence farmers around the world, climate change and variability is a significant stressor that challenges their livelihoods and well-being. Providing credible, actionable information about the weather and climate to these farmers has the potential to alleviate a source of livelihoods risk, improve food security and incomes, and therefore serve as a foundation upon which locally appropriate, innovative approaches to new livelihoods can be built. However, designing and delivering such climate services to subsistence farmers is a complex process. Useful climate services must identify the information most useful and actionable for targeted communities, must identify means of communicating this information in a locally-appropriate manner, and must develop means of conveying the uncertainty of historical, real-time, and forecast information, and appropriate means of addressing that uncertainty in one's agricultural strategy.

In June 2011, USAID organized a West African Adaptation Workshop under the Adaptation Partnership in Dakar, Senegal. The workshop had several goals, including improving the awareness of and demand for climate services in the region among decision-makers in various sectors, improving climate service providers' understanding of decision-makers' needs, identifying opportunities to design and deliver climate services for decision making, and sharing information on good practices and models. At that meeting, representatives of Mali's Direction Nationale de la Météorologie (National Meteorological Directorate, henceforth Meteo Mali) gave a presentation about their ongoing agrometeorological advisory program. The results they reported were impressive, with reported yield increases of 20-60%, depending on the part of the country in which the information was used. Impressed by what they had seen, participants from several Sahelian countries expressed interest in starting similar programs. To facilitate this process, USAID commissioned this assessment of the Malian agrometeorological program.

This assessment has several related goals. First, the assessment aims to independently evaluate the impact of the agrometeorological program on agricultural outcomes in Mali, providing necessary credibility to justify the transfer of similar programs to new countries. Second, through its evaluation of program operation, function, and outcomes, the assessment seeks to provide a set of criteria that can inform the programming, design, and implementation of climate services for farmers in the Global South. Finally, the assessment will contribute to a very small body of knowledge on the workings and efficacy of climate services for smallholder farmers in sub-Saharan Africa, and the Global South more broadly. In this way, USAID is positioning itself as a thought leader on this subject.

This is the first of two reports that will comprise the full assessment. This report contains an assessment of the forecasts and science behind the advisories themselves, and an assessment of the use of the agrometeorological advisories at the community, household, and individual level in Mali. Because the social dynamics shaping the use of climate information in agriculture and livelihoods more broadly are complex, a full appraisal of the working and impact of the program for farmers will require additional qualitative fieldwork, the results of which will be covered in a second report. This report also contains recommendations for activities and actions that might enhance the working of Meteo Mali's program now, and identifies future research needed to develop a fuller understanding of the use of advisories by farmers, both for use in the Mali program, and to define criteria that can inform the programming, design, and implementation of climate services for farmers.

# 2. BACKGROUND AND FUNCTION OF THE AGROMETEOROLOGICAL ADVISORY PROGRAM

*ABDOULAYE MOUSSA, ICRISAT; KALIFA TRAORE, INSTITUT D'ECONOMIE RURAL*

## 2.1. HISTORY

In the late 1960s, Mali began to experience persistent drought, with annual precipitation well below the anomalously wet 1950s and 1960s. In 1974, an accumulation of these dry years contributed to a famine that heavily impacted the West African Sahel. Mali was one of several states that suffered through this situation. In the wake of this drought, as well as other dry years in the 1970s, it became clear that rural communities needed help in managing the risks associated with rainfall variability.

In 1977, in response to the repeated incidence of food insecurity in the country, two young scientists, Kaliba Konaré and the late Mama Konaté, began to question how the effective use of meteorological (weather and climate) information, particularly at the grassroots level, might address national development issues, including drought. More specifically, they were interested in how to transform science-based weather and climate information into relevant user-friendly products for farmers in order to assist them in cropping activities and increase their agricultural productivity. In aiming to address this issue, the two developed a concept note that would eventually lead to the agrometeorological program in place today. The concept note laid out three key objectives:

- Assess farmers needs and requirements regarding weather and climate information services;
- Provide weather and climate information services to farmers through appropriate channels and ensure effective use by farmers; and
- Demonstrate the benefits, if any, of the use of weather and climate information and services to the farming community and policy makers.

In 1982, at the start of another multi-year dry episode, the Mali meteorological service took up this concept note, embarking on a pilot project to bring agro-meteorological information to rural communities and authorities and help them in their decision making concerning farming activities and food security: the *Programme d'assistance agro-météorologique au monde rural* (Agro-meteorological assistance program for the rural world) with support from the Regional Centre for Training and Application in Agrometeorology and Hydrology (AGRHYMET), the World Meteorological Organization (WMO), and funding from the Swiss Agency for Development and Cooperation (SDC). During the lifetime of the program, financial support was also provided by Italian and Spanish Cooperation. Following the Konaré/Konaté concept note, the project envisioned climate information as a critical input to farmers in their agricultural and food security decision-making. Further, the project sought to build farmer capacity for climate-related decision-making, such as by enhancing their capacity to measure rainfall themselves. As an example of a national hydrological and meteorological service supplying climate-related advice and recommendations directly to farmers and local communities, and empowering those communities and farmers to better address climatic factors in their decision-making, the project was highly innovative. Thirty years on, the program continues, having transitioned from a donor-funded effort to a Government of Mali-funded program.

## 2.2. AIMS OF THE PROGRAM

The pilot project's broad aims were to identify whether and how climate information could be useful to rural farmers to assist them in making informed decisions in their farming activities and food security to alleviate the impacts of drought. These questions were addressed through a series of specific objectives:

- The sensitization of rural communities to the use of agrometeorological information by assisting them to be directly involved in the various activities, through teamwork and a chain reaction network, involving extension workers, agricultural officials, and policy makers;
- The provision of professional training for local farmers and their introduction to data collection and the practical use of meteorological and agro-meteorological information in all agricultural decision making processes;
- The establishment of a functioning system of compilation and dissemination of agro-meteorological information and advice to rural communities;
- The preparation of forecasting tables to determine when to begin the main planting seasons; and
- The establishment of a rural database (on agrometeorological information) to help with agro-meteorological work and operations.

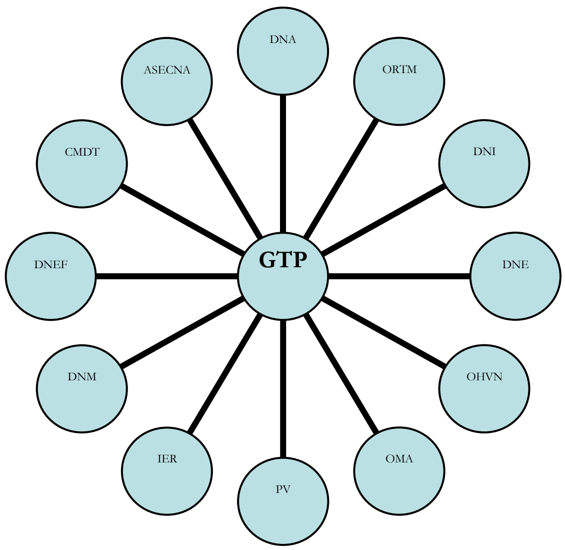
## 2.3. PROGRAM IMPLEMENTATION

### 2.3.1. INITIAL INSTITUTIONAL ORGANIZATION

Program activities were initiated through the "Equipe de Travail Pluridisciplianire (ETP)" (known at ETP). ETP members were extension services of the High Niger Valley Office (OHVN) "Office de la Haute Vallée du Niger" (OHVN), the Malian Company for Textile Development (CMDT), the Rice Office at Segou (ORS), the Rice Office at Mopti (ORM), and the Regional Agricultural Directorate (DRA). ETP members were in charge of elaborating agro-advisories to farmers involved in the experiment and provided feedback to OHVN. The use of the term "team" (*equipe*) in the name of the ETP working group was deliberate, because members were not only to represent their respective organizations but also to bring specialized expertise in their area of intervention/interest. ETP members met every 10 days to discuss the agro-advisories to farmers. Although several national institutions participated, the ETP worked in an informal way without any formal legal status. The approach was to promote participation and volunteerism among the different stakeholders and actors involved in the project and thus limit cumbersome administrative processes. In the years since the project was started, ETP's most important functions has been to act as a "boundary organization," bridging the gap between the climate and agricultural communities by interpreting climate information in order to provide advice to farmers.

The multidisciplinary nature of the group also allows different expertise to be brought to bear on agriculture and food security problems. Later, AGRHYMET built on this innovative concept, applying it in CILSS countries as Multidisciplinary Groups (Groupe de Travail Pluridisciplinaire – GTP). From 1981, ETP members were then connected to the GTP established by AGRHYMET/CILSS at the national level. Figure 1 below provides a list of the members of the GTP. The multidisciplinary working group was at the heart of the information flow from information providers to the end-users and vice-versa. Each of the GTP members was responsible for providing specific input as per its areas of expertise:

- A wide range of GTP members encompassing extension and public services collected information to build user-defined and demanded climate-related data and products;
- The Meteorological Service analyzed technical aspects of climate-related data and products;
- The Ministry of Agriculture, extension services, and research groups worked on issues such as crop production, crop varieties selection, crop health/protection, soil management, and soil fertility;
- The rural development agencies focused on capacity building of farmers and extension services; and
- The media sensitized users and disseminated climatic and agro-meteorological information.

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|---|---|
| DNA | National Agricultural Directorate |
| ORTM | National Radio and Television |
| DNI | National Internal Affairs Directorate |
| DNE | Livestock National Directorate |
| OHVN | Office of the High Niger Valley |
| OMA | Agricultural markets observatory |
| PV | Crop protection service |
| IER | Institute of Rural Economy |
| DNM | National Meteorological Directorate (Meteo Mali) |
| DNEF | National Water and Forestry Directorate |
| CMDT | Malian Cotton development company |
| ASECNA | Agency for the Safety of Aerial Navigation in Africa |

**Figure 1: Members of the multidisciplinary working team (ETP).**

Unlike the ETP, the GTP members were representatives of their institutions and not necessarily experts or scientists. The GTP was doing drought monitoring and reporting accordingly, which was useful to the decision-makers, particularly at policy level. The GTP product (via bulletins) was also taken as an input to the National Early Warning System on Food Security countrywide (at least vulnerable zones). Thus, initially there were two working groups running in parallel. In 1993, the ETP and GTP were merged to become the GTPA (Groupe de Travail Pluridisciplinaire d'Assistance Agrométéorologique).

## 2.3.2. IMPLEMENTATION PHASES

### 2.3.2.1. EXPERIMENTAL PHASE (1982 – 1986)

As a first step, ETP staff visited farmers to ask what kind of information might be useful to them. Overwhelmingly, farmers requested information on the onset and end of the rainy season and the amount and distribution of rainfall. Efforts were then made to enable farmers to access the kind of information that could best address these stated needs. The experimental phase started with a pilot project in 1982 (Figure 2) with 16 volunteer farmers who were growing pearl millet, sorghum, maize, cotton, and groundnut in the southern part of the Koulikoro region. Target users were identified after exchanges with OHVN, DNA, IER, and alphabetization (adult literacy) services. The Siby area in Koulikoro region was the first pilot test area because of its accessibility (it is near Bamako), the farmers' level of collaboration with ETP-associated organizations, and the physical characteristics of the site (not too dry and not too wet). Four villages (Bancoumana, Kenieroba, Kongola, and Magandiana) were selected for experimentation. In Bancoumana and Kenieroba, the focus was on sorghum. In Kongola and Magandiana, millet was the focus. Four test farmers were chosen by researchers in each village, for a total of 16 farmers.

Each farmer managed two plots, one experimental plot in which they made decisions based on agrometeorological information and another in which they relied on traditional indicators – including the appearance of certain birds, the dropping of fruits from certain trees, and the movement of termites – to help them decide when to prepare fields, how and what to sow, when to weed, and when to apply inputs such as fertilizer and pesticide. Farmers in the pilot project were able to transmit their experience to their neighbors, providing knowledge to the farming community as a whole.

The farmers were given gauges to measure rainfall in their fields and were trained in how to use the measurements to help them make decisions based on sowing calendars, which indicated suitable planting dates and appropriate crop varieties depending on rainfall. Farmers received 10-day bulletins that, while including daily and three-day weather forecasts, also provided information on current hydrological, meteorological, agricultural, pest conditions, and advice that translated the forecasts into actionable agricultural advice. Farmers were regularly visited by ETP staff, who gathered feedback to improve the project.

#### 2.3.2.2. DEMONSTRATION/EXTENSION PHASE (1986 – 1990)

The 16 volunteer farmers saw promising results after the first year of the pilot project. In the experimental plots, participants recorded millet and sorghum yields 25%-30% greater than non-participants in the southern part of the country, and 40%-60% greater in the north. In light of these results, there was an increasing demand from neighboring communities for rain gauges, agro-meteorological information, and training.

#### 2.3.2.3. SCALING-UP PHASE (1990-2005)

Scaling the pilot project up into a program began in earnest with a large stakeholder workshop in 1993. During the workshop, participants evaluated their activities from 1989 to 1993. The workshop provided the motivation to extend the program activities to other regions (Kayes, Koulikoro, Sikasso, Segou, and Mopti), increasing the number of participating farmers. During this phase, the GTPA and ETP were merged under the name GTPA. Further:

- Over 50 bicycles were provided to representative farmers to facilitate the recording and transmission of rain gauges data to the nearest synoptic meteorological station for transmission to the national meteorological service;
- Local rain gauges were manufactured to replace more expensive imported rain gauges;
- Climate and agrometeorological information was provided to an expanding number of farmers' organizations, rural programs, development agencies, and NGOs; and
- Representative farmers were regularly visited by the GTPA. Three visits were organized every year by the GTP: a) at the onset of the rainy season, b) mid-season and c) at the end of the rainy season, when crop yields were also estimated. During these visits, farmers discussed the program and their needs with the GTP. The feedback was then shared and discussed during the GTP meeting, and recommendations formulated to address the major concerns raised by the farmers.

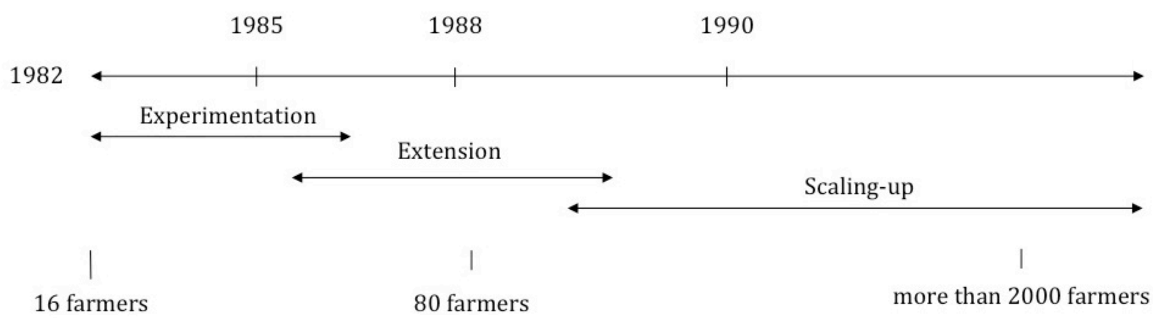


**Figure 2: Program implementation phases.**

### 2.3.3. EVOLUTION OF THE END-USER POPULATION

Although no formal records exist to accurately account for the number of farmers that have adopted and/or used the information, it is clear that the number of end-users has expanded as the program developed through its successive phases.

### 2.3.4. PRODUCTS AND SERVICES PROVIDED

Since its inception the program has provided farmers with rain gauges to measure rainfall in their fields, and were trained in taking measurements and using them in conjunction with sowing calendars, which indicated suitable planting dates and appropriate crop varieties in the different locations. The collected rainfall data reached the multidisciplinary working group, and was processed during the GTP's fortnightly meetings. During these meetings agro-meteorological opinions, warnings and advice were formulated by the GTPA, and then circulated to local communities by means of national radio and television.

Advice given to rural communities generally dealt with the following:

- Agro-climatic reference tables, for planning agricultural activities such as: mobilization, field clearing, and the use of different varieties of seeds and pesticides, etc., based on the hydrological reports and daily weather forecasts;
- The right time to begin the planting season, with the help of planting forecast tables, daily rainfall figures, hydrological reports, and daily weather forecasts; and
- The outbreak of certain crop diseases, especially mildew (warning based on rainfall, temperature, and humidity).

Initially, the pilot project provided two major products.

- Ten day bulletins with summary information on hydrological, meteorological, agricultural, and pest conditions, as well as corresponding advice and recommendations; and
- Three-, seven-, and 10-day weather forecasts.

These two products were the first provided to the farmers, and continue to be delivered to date. However, following the increasing farmer demand for additional products, the GTPA added the following products:

- Estimates of water requirements of the different crops in each of the major agro-climatic zones;

- Crop water balance computations at the end of each dekad (10-day period);
- The probability that the rainfall for the next 10 days will be equal to or greater than the climatological plant water demand for that specific 10-day period;
- Climatological crop calendar;
- Climatological sowing dates; and
- Dry and wet spells.

### 2.3.5. MONITORING AND EVALUATION

In 1993, the program held its first stakeholder workshop to encourage participants to evaluate activities. From 1993 to 2005, evaluation workshops were held every two years in each of the six districts where the program was implemented.

Staff from the NMHS presented several communications at high-level policy events (e.g., Council of Ministers, Parliament Session) to update the State and policy decision-makers on the status of the project. This regular sharing and communication of information on the project has led to a strong buy-in by the Malian Government.

### 2.3.6. PROGRAM FUNDING

The Swiss Agency for Development and Cooperation (SDC) provided funding for 23 years (from the onset until 2005) for the Mali agrometeorological program, before handing over full responsibility for project planning, management, and financing to the Government of Mali. Starting in 1993, the Malian government also recognized the positive impacts of this program and endorsed it with a financial commitment to strengthen Meteo Mali. Improved buildings for Meteo Mali opened in 2004, and about US$1.2 million was allocated for new weather stations and equipment in 2005–06. This involvement facilitated smooth transition in handing over the program to the Government of Mali that ensured program sustainability and demonstrated national ownership as a desirable capacity development element.

Italian Cooperation and Spanish Cooperation provided other financial supports for specific activities such as meteorological advice to farmers (Italian Cooperation in 1995) and roving seminars (Spanish Cooperation). With the assistance of WMO and the Spanish Meteorological Agency, these seminars were held at the local level, in communities throughout the country. Like the program itself, the overarching goal of these seminars is to increase agricultural production through the development of skills that lead to the effective management of climate risks and the rational use of natural resources. Specific objectives include informing farmers on the effects of weather, climate, and climate change on rural activities; distributing and training farmers on the use of rain gauges; and developing a core group of farmers to further collect weather and climate data. To date, more than 2,500 farmers have participated.

## 2.4. ENABLING AND CONSTRAINING FACTORS

While our full institutional assessment of the Mali Agrometeorological Program is not yet complete, initial investigations into the institutional set-up and function of the program provide some preliminary, provisional lessons with regard to the opportunities and challenges facing new programs that seek to provide climate services to farmers in the Sahel.

### 2.4.1. KEY FACTORS ENABLING PROGRAM IMPACT

Over the lifetime of the program, several factors have contributed to shape the success and notoriety of the project. The following summarizes the main key enabling factors of success:

- The multidisciplinary team work and approach used at the onset of the pilot project that brought together many relevant public agricultural-related services;

- The program's farmer-centered approach, which has led to the development and delivery of climate products and services to meet their needs;
- The sustained relationships among diverse groups of stakeholders;
- Translation of the information into multiple local languages in more user-friendly formats to ensure effective use and sustain the agricultural sector;
- The solicitation of user feedback as the engine that drove the process;
- Innovation, creativity, and realism in the design of the program;
- Commitment by the Government of Mali in 2001 to strengthen the meteorological service;
- National buy-in of the project and political support for the Mali NMHS by the government;
- Long-term support from the SDC as well as technical backstopping from WMO and AGRHYMET;
- Effective communication channels, especially between the multidisciplinary working group that facilitated information flow between representative farmers and the climate information providers at the national and regional level;
- Working and building on existing public decentralized services (agriculture, livestock, fisheries, environment, etc.) at the local level;
- Human capacity is key and requires continuous investment; and
- Use of radio as en effective medium for information dissemination.

### 2.4.2. KEY FACTORS CONSTRAINING PROGRAM IMPACT

In the process of implementation, the program has identified limitations that challenge the overall impact of its advisories and outreach efforts:

- Limitations in providing downscaled (at the village level) forecast information to farmers;
    - Ongoing decline of the national rainfall stations/observatories that limited more accurate, location-specific forecasting;
    - Challenges in the development of relevant climate products due to the limited funding and human resources of the national meteorological service;
    - Limited availability of data collection sheets; and
    - Difficulties in accessing needed meteorological data;
- Low literacy levels and little formal education among farmers, creating challenges in the translation of scientific information into language accessible to farmers;
- Limited funding for agriculture extension officers, which resulted in fewer field visits to farmers and turnover of staff critical to the dissemination of advisories;
- No funding to sustain research and development activities;
- The program only focused on one aspect of people's livelihoods-agriculture – to truly impact overall incomes, the program would have had to address livestock, forestry, and fishing issues;
- Private communication channels were not well developed at that time and only ORTM was available as an information conduit; and
- Methodological issues. For example, the effects of fertilizer and meteorological advisories were not disaggregated in program evaluations, so it was impossible to determine the actual value of particular forms of meteorological information so that they could be identified and expanded upon.

# 3. PROGRAM ASSESSMENT

The assessment of the Agrometeorological Advisory Program consisted of three parts: An institutional assessment managed by CCAFS; a field assessment managed by a collaborative team from USAID, the University of South Carolina, and CCAFS; and a science assessment managed by IRI. We discuss the goals and findings of each part of the assessment in this technical report.

## 3.1. INSTITUTIONAL ASSESSMENT

The planned institutional assessment of the Agrometeorological Advisory Program was not completed in time for this report. The ICRISAT/CCAFS staff tasked with this responsibility developed the institutional history of the program used at the introduction of this report. However, despite a generally positive reception from key individuals involved in the program, the ICRISAT/CCAFS staff found it exceptionally difficult to get enough individuals to respond with adequate answers to important questions needed for a thorough assessment. The assessment team on the whole has determined that surveys are inadequate for this task, as the population that must be assessed is very small, and response rates on surveys are usually quite low. The assessment team is redesigning the institutional assessment, and working with colleagues associated with USAID's ARCC program to identify the human resources necessary to conduct phone or in-person interviews with these key actors.

## 3.2. ASSESSMENT OF CLIMATE SCIENCE USED BY DIRECTION NATIONALE DE LA MÉTÉOROLOGIE DU MALI FOR PROVISION OF AGROMETEOROLOGICAL INFORMATION TO THE RURAL COMMUNITY

*SIMON MASON, IRI; ALE GIANNINI, IRI; TUFA DINKU, IRI*

Mali's climate is marked by the alternation of dry and wet seasons, with the latter as short as three months, from July to September, in the Sahelian center. The country experiences a maximum of about 1,200 mm per year in the far south-west to less than 200 mm per year in the desert northern half (1971 – 2,000 averages). However, it is the year-to-year variability in rainfall rather than the averages that make the country particularly sensitive to climate. Rainfall is highly erratic throughout Mali, and droughts are both frequent and intense. From 1972 to 1984, a series of particularly severe drought-related famine events affected Mali and the broader Sahelian region (Hulme, 1992). More than 100,000 people died and 750,000 were completely reliant on food aid in the region (UNEP, 2002).

A decline in rainfall through the 1970s and 1980s over the broad Sahel represented the largest sub-continental scale change in observed rainfall on this timescale anywhere in the world (Dai, Trenberth, & Karl, 1998). The decline was primarily associated with decreases in the frequency of rainfall compared to earlier decades rather than with decreases in rainfall intensity (Le Barbe, Lebel, & Tapsoba, 2002), which is unfavorable from an agricultural perspective. The causes of the drought have been actively researched, but the current consensus is that changes in the temperature of the tropical Atlantic and Indian Oceans have been primarily responsible (Giannini, Saravanan, & Chang, 2003) rather than changes in land use that might be associated with increasing population pressure and migration (Nicholson, Tucker, & Ba, 1998).

These trends and variability in climate in Mali have contributed to the country's struggles with persistent food insecurity. According to the World Bank, 26% of low income Malians (those making less than $1035/yr) are undernourished. While less than 4% of Mali's land-area is suitable for cropping, 80% of its population depends on agriculture for its livelihood. With a heavy dependence on rainfed agriculture, and a highly erratic rainfall regime, year-to-year variations in the country's national cereal production, for example, are highly correlated to rainfall, which highlights the vulnerability of the population to climate change and variability.

### 3.2.1. METHODOLOGY USED FOR ASSESSMENT

The goal of this assessment is to understand what climate information is generated by Meteo Mali and how it is translated and disseminated to users. It has the following objectives:

- Identify what climate information is provided to farmers currently;
- Assess the scientific basis for the climate information provided and its relevance;
- Understand the translation and dissemination process;
- Identify opportunities for improving the quality and relevance of the climate information products currently provided; and
- Identify challenges Meteo Mali has encountered in satisfying specific user needs.

#### 3.2.1.1. APPROACH

The approach has four main components:

1. Review of available literature;
2. Engagement with colleagues at Meteo Mali to learn about their methodologies through interview and discussion;
3. Consultation with individuals from relevant organizations such AGRHYMET and ACMAD; and
4. Analysis of the collected information.

Literature review

There are limited publications available in English about Meteo Mali's experience (Hellmuth, Moorhead, Thomson, & Williams, 2007). There may be some more documents available in French at Meteo Mali, but they have not been appropriately catalogued since Meteo Mali moved to its new headquarters in about 2005. Available documents were reviewed to get first impressions on the Mali experience.

Engagement with Meteo Mali

The main source of the information for this report was direct exchange between the science team and Meteo Mali staff. In late January 2012, the science team traveled to Bamako, Mali, to engage in in-person, in-depth discussions with the leadership at Meteo Mali – a group of about 5–10 people who have advanced in their careers as the program developed over the decades since 1982[1]. The interviews and discussions were held during two half-day visits to the Meteo Mali headquarters.

The first day was a general discussion with individuals representing Meteo Mali leadership. This was meant to give Meteo Mali a chance to describe the evolution of the program from its own perspective. The first day's general discussion was followed by individual interviews the following day with Daouda Zan Diarra (Agrometeorology division), the public face of the program, and with Mohamed Koité

[1] At the time of the visit of the science team, Meteo Mali had recently lost its dynamic director, Mama Konaté, who was very active in representing Africa in climate change/adaptation negotiations at international level.

(Research and development division) in charge of developing forecasting methodologies. The interview with Diarra explored details of the outreach aspects involving farmers as providers and recipients of climate information. That with Koité explored the science behind forecasting methodologies.

Consultations

Before visiting Meteo Mali, the science team, together with Diarra and Koité from Meteo Mali, participated in the opening session of training in preparation for the field assessment campaign. At this session the science team was exposed to a multiplicity of perspectives on the reasons for the peculiar evolution of the Malian program of assistance to the rural communities. Most notably, Maty Ba Diao, representing of AGRHYMET, recalled how from its own institution's perspective, Mali's program of assistance to rural communities is one example of the successful implementation of the concept of the GTPA (Groupe de Travail Pluridisciplinaire d'Assistance Agrométéorologique), which it promoted. In addition, the Agromet program has benefitted from the development of climate information through the *PRÉvisions Saisonnières en Afrique de l'Ouest* (PRESAO) – the seasonal outlook forum for West Africa, coordinated by ACMAD.

Analysis

The inputs from the three different sources were analyzed to answer the major questions, including:
- What climate information is provided?
- How is the data collected, processed and delivered?
- What are the forecasts provided and at what time scales?
- How are these forecasts translated and delivered?
- What methodology is used for preparing forecasts and how does it compare to "standard" methods in Africa and elsewhere?
- What are the gaps between the information currently provided and that are needed by farmers?

## 3.2.2. DATA COLLECTION AND GENERATION OF INFORMATION PRODUCTS

This section describes climate information collected, products generated and how they are generated, and what use the products are intended for. This analysis focuses mainly on two basic types of climate information: observation and forecast. The generation and use of information products based on these two information types are presented separately.

### 3.2.2.1. DATA COLLECTION AND TRANSMISSION

Meteo Mali is responsible for the collection, archiving and analysis of basic agrometeorological data. Agrometeorological data consists of rainfall, temperature, wind, humidity, and sunshine hours. In addition to agricultural extension workers and observers at agrometeorological stations, rainfall data are recorded by Local Meteorological Support Groups (*Groupes Locaux d'Assistance Meteorologique*, henceforth GLAM) and by thousands of volunteer farmers – a unique attribute of the Agromet Advisory program being evaluated. An affordable "farmer rain gauge" was developed locally for this purpose. The other parameters are collected only at the agrometeorological stations. Rain gauge stations measure only rainfall, while synoptic and agroclimatic stations also measure other climate variables. Synoptic stations are used in the international meteorological data exchange system. In Mali, there are many more rain gauge stations than there are agrometeorological stations (Figure 3). The number of rain gauge stations increased significantly in the 1950s, then steadily until the late 1980's, after which some decline is observed (Figure 4). This evolution is generally typical of many parts of Africa, and generally a product of some combination of the post-colonial difficulty of funding an extended network of stations and the advent of satellite observations. The agrometeorological data are transmitted to Meteo Mali at the end of each dekad (10-day period) during May to October via radio or telephone. A number of bicycles have also been provided to volunteer farmers to facilitate the transmission of rain gauge data to the national meteorological services, via regional offices.

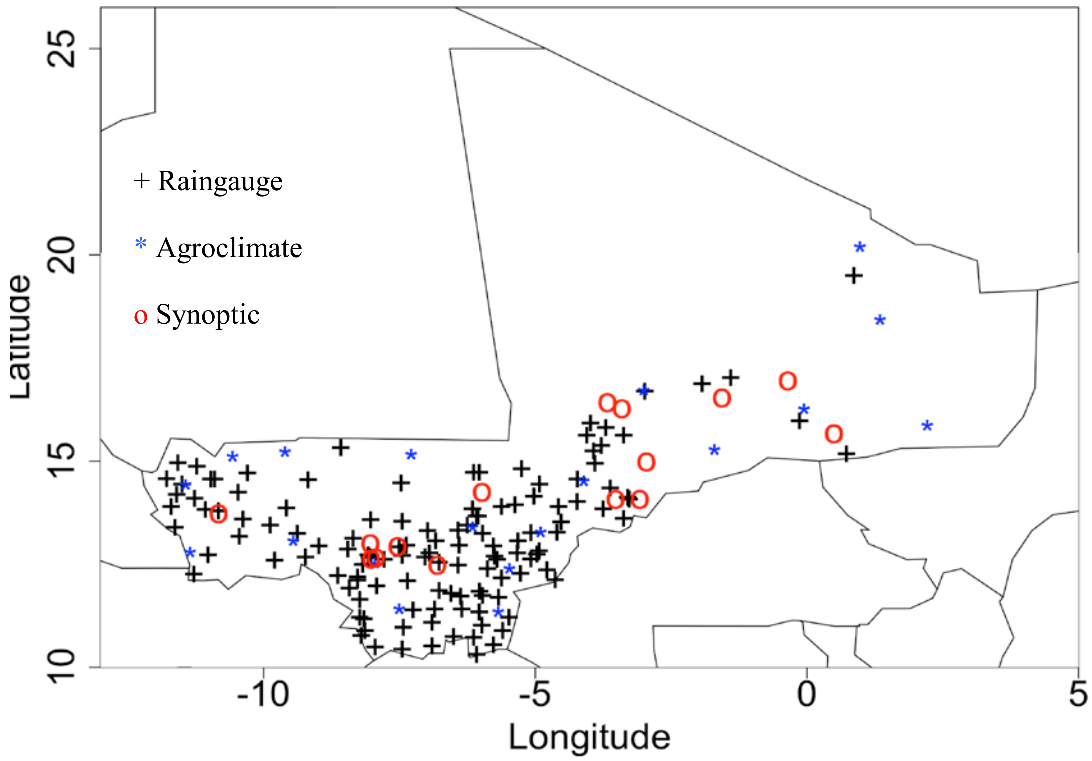


**Figure 3: Mali's network of meteorological stations (does not include farmer rain gauge stations).**

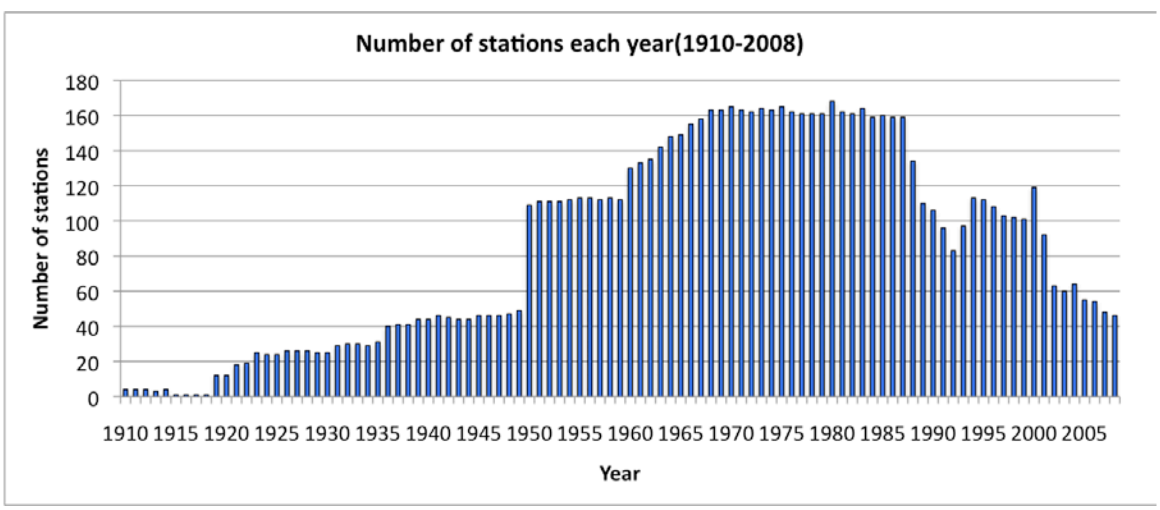


**Figure 4: Number of stations reporting rainfall over Mali during 1910 – 2008 (based on analysis by Mamadou Samake (AGRHYMET)).**

Forecasts

The Meteo Mali currently issues forecasts at daily, weekly (since 2007) and seasonal (since 1998) temporal resolutions. The spatial resolutions range from the sub-regional scale of the daily forecast, where a "region" is one of nine first-level administrative boundaries below national, to the five climatological zones of the seasonal forecast depicted in Figure 5. During the course of the multi-decadal history of the agrometeorological program of assistance the Meteo Mali has actively sought opportunities to improve capacity, with extended multiple staff visits to the Africa Desk of NOAA's Climate Prediction Center, the University of East Anglia, the UK's Met Office, Météo-France, and the Korean Meteorological Agency. Likewise, Meteo Mali staff have proactively sought to engage with regional institutions to share the capacity acquired, most notably requesting ACMAD's involvement in the refinement of seasonal climate forecast methodologies based on state-of-the-art scientific knowledge.

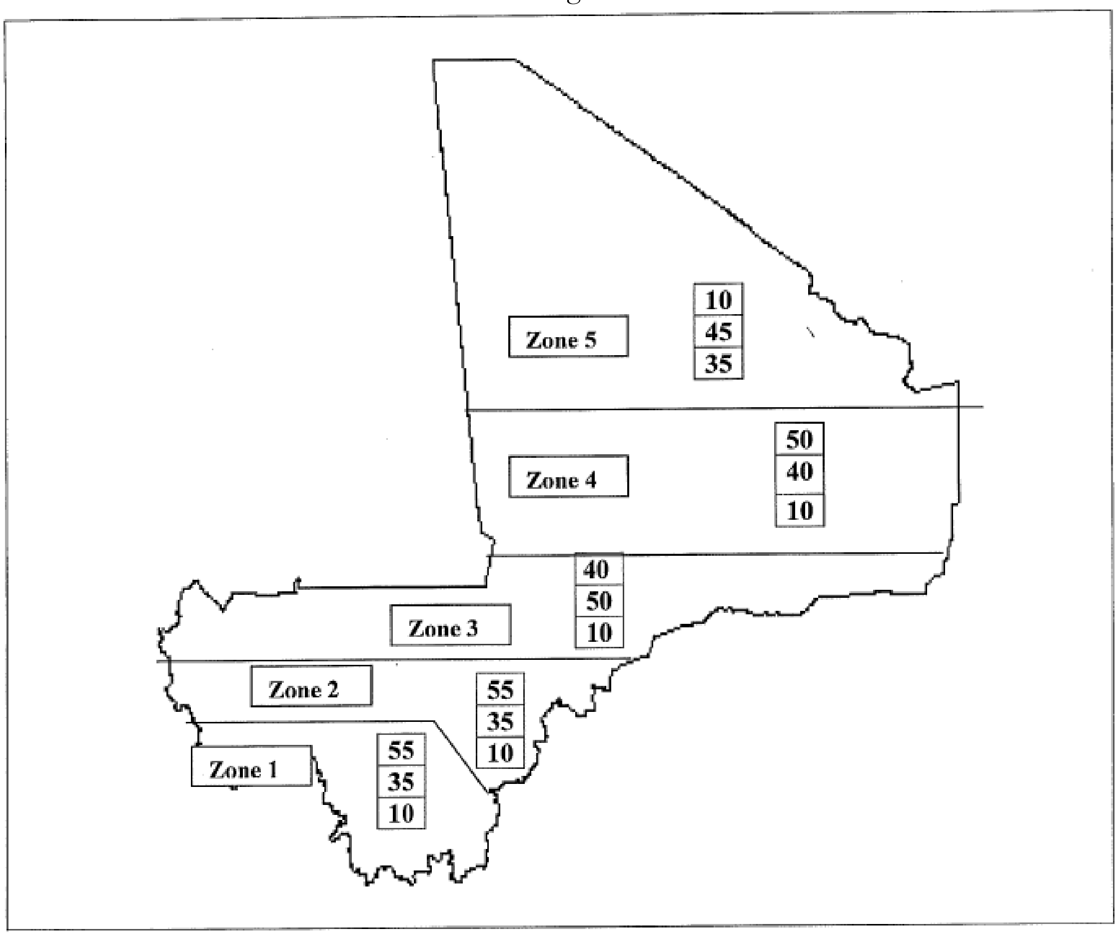


**Figure 5: Map of the 5 climatological zones used in Meteo Mali's seasonal climate forecasts, together with example tercile-based forecast probabilities.**

Daily forecasts

The daily weather forecast, broadcast three times a day in French and in local languages, consists of rainfall, temperature and wind forecasts for broad areas, usually at least as large as a *cercle* (the second-level administrative unit in Mali, typically roughly 20% of a region). The Meteo Mali has the capacity to produce the videos in-house, which are then broadcast on national television.

Weekly forecasts

The weekly forecasts during the rainy season were started in 2007, and are based on following the dynamics of the monsoon. They combine regional observation of monsoon dynamics, such as the depth and northward progression of the humid layer, with products developed by WMO Global Long-range forecast producing centers, e.g., to monitor the displacement of the Inter-Tropical Front or to monitor and predict phases of the Madden-Julian Oscillation. The weekly forecasts include temperature and rainfall, but focus on rainfall outlooks for each day and whether to expect weak, moderate or strong rainfall events. As with the daily forecasts, these are generally given for *cercles* or larger areas within the country.

Seasonal forecasts

Seasonal rainfall forecasts made their debut in Mali in 1987. Farmers had been demanding it, and Meteo Mali seized the opportunity to exploit the first experimental forecasts made by the UK Met Office for the Sahel. The impetus for trying seasonal forecasting for the Sahel at the Met Office came from the pioneering modeling work of Folland et al. (1986), which had shown the dominant influence of global sea-surface temperatures on the climate of this region. However, the forecasts seemed to be of poor skill, and another decade went by before a concerted international effort emerged in the form of PRESAO.

Meteo Mali started operational seasonal forecast in 1998, following the first PRESAO, where each participating country developed a deterministic statistical forecasting method based on sea-surface temperature predictors (ACMAD/WMO, 1998). The forecasts for 1998 proved to be very beneficial: the rainfall season started late in 1998 and the farmers were ready to give up on the season, but a La Niña event was developing on the heels of the strongest El Niño of the 20$^{th}$ century, giving Meteo Mali scientific basis for assuring farmers that the rain would come and that the season would be good. That was what happened – the expected influence of a La Niña event developed and seasonal rainfall was abundant, and continued into November. As a result, Meteo Mali claimed to "have saved Mali's agriculture". It was a very good start for Meteo Mali's credibility, though very risky given the probabilistic nature of seasonal climate forecasting.

The methodology used by Meteo Mali for seasonal prediction is purely empirical, and relies on one or more predictors chosen among a set of sea-surface temperature anomaly indices identified through a regional analysis (see ACMAD/WMO, 1998; Folland et al., 1986). Five predictors have been identified at the regional level, which are the combinations of sea-surface temperature anomalies of different months (mainly April and May) over the following regions:

1. Equatorial Atlantic (0°-10°S, 20°W-10°E);
2. Northwest Atlantic (20°-40°N, 30°-10°W);
3. Equatorial Pacific (10°S-10°N, 150°-90°W); and
4. The 3$^{rd}$ principal component of global sea-surface temperature.

These predictors are used in multiple linear regression models to compute deterministic forecasts of total seasonal rainfall. A different multiple linear regression model is employed for each of five zones into which Mali is divided (Figure 5) in light of the dramatic variation in climatology, from arid desert in the north (zones 4 and 5) through semi-arid Sahel in the center (zone 3) to Sudanian savanna and Guinean forest in the south (zones 1 and 2).

Meteo Mali has tested the different models using cross-validation approaches. The direct output of the statistical/regression model is a standardized anomaly. This anomaly is then compared to the historical distribution, and converted into a tercile-based probabilistic forecast (Figure 5), depending on where the anomaly falls in the tabled values of historical data going back to 1950, whether the above-normal, normal- or below-normal category. Where the anomaly falls is bracketed by years that are then used as analogues to translate the seasonal forecast into its intra-seasonal development, to help translate into advice for farmers.

#### 3.2.2.2. PRODUCTS AND PURPOSES

Meteo Mali produces and disseminates an array of information products at daily, dekadal, monthly, and seasonal time scales. The main data products generated for specifically for the Agromet Assistance program include the following:

- Climatological crop calendar;
- Climatological sowing dates;
- Estimates of water requirements of the different crops in each of the major agro-climatic zone;
- Crop water balance computations at the end of each dekad;
- Dry and wet spells; and
- The probability that the rainfall for the next 10 days will be equal to or greater than the climatological plant water demand for that specific 10-day period.

The key for the generating useful products is the combination of agronomic research outputs with historical and current agrometeorological information. The crop calendar provides information on the climatological start and end of the rainy season and the length of the growing period (Direction Nationale de la Météorologie, 2003). The method of Franquin (1978) has been adopted to construct a reference (climatological) crop calendar for each region using rainfall and potential evapo-transpiration (PET). PET is estimated from agrometeorological observations using the method of Ferer and Popov (Frere & Popov, 1979, 1986). Sowing date has been given the most importance because it determines the length, and hence the success or failure of the growing season. To start with, climatological sowing dates are determined for each crop type and each agrometerological zone using historical climate time series. The approach used is that of Forest (1984), which is based on crop water balance calculations. The most suitable climatological sowing date is determined using actual evapotranspiration (AET) and maximum crop evapotranspiration (MET). AET is computed using Eagleman's (1971) function while MET is a function of crop coefficient and PET. The AET/MET ratio defines the crop water requirement satisfaction index. The success of the growing season is then defined in terms of the product of this ratio during three important phases of the crop. The minimum probability of success is set at 80% so that the probability of failure is just 20%. This is meant to insure favorable soil moisture conditions for germination and sprouting (Direction Nationale de la Météorologie, 2003). Delayed sowing dates may mean choosing a different crop variety. The Meteo Mali has developed a practical guide to sowing dates with 80% of success for different crops and different regions (e.g. Direction Nationale de la Météorologie, 2003). These guidelines for optimal planting dates (when there is enough moisture in the soil) have been translated into different local languages. These climatological sowing data are used along with calculations of water balance at the end of each dekad to advise farmers on suitable dates for sowing and other activities. These are meant to help farmers and extension workers make informed-decisions about different aspects of agricultural activities.

**Table 1: Provides an example of recommendations based on climatological sowing dates (Direction Nationale de la Météorologie, 2003):**

| Table 1: Example recommendations based on sowing dates. |
|---|
| Locality: District of Bamako.<br>Crop: Millet/Sorghum.<br>Cycles: 120 - 90 days.<br>Recommendations:<br>i. Avoid sowing before May 31st, but proceed with land preparation.<br>ii. 3 to 30 June: sow a variety with 120-day cycle during which 10-day total rainfall should be greater than or equal to 20 mm.<br>iii. 1 to 20 July: sow 90-day variety during which 10-day total rainfall should be greater than or equal to 20 mm<br>iv. Avoid sowing 90-day varieties after July 20, but choose a variety with shorter cycle. |

The above information is supplemented by 10-daily bulletins, which advise the farmers what to do given the current and expected status of the season.

The following is an excerpt from the dekadal bulletin for the 1st dekad of June 2011.

*"The farmers in the district of Bamako and surrounding areas of Koulikoro, Koulikoro, Kati, Bafoulabé, Bankass, and Koro can sow millet, maize and peanut with cycles of four months when the total rainfall received during 11 to 20 June is more than 20 mm."*

This information is used by the farmers in combination with rainfall data recorded by themselves.

#### 3.2.2.3. MAJOR GAPS IN THE INFORMATION PROVIDED

- Difficulty of providing reliable local-scale forecasts regarding the onset of the rainy season and the timing of possible dry spells;
- Need for monthly forecasts;
- Need to translate seasonal forecast information into specific advice and recommendations to farmers; and
- Lack of verification information.

### 3.2.3. TRANSLATION AND DISSEMINATION OF INFORMATION

Translation of the agroclimatic information into useful advice and recommendations is the responsibility of the multi-disciplinary working group (GTPA). The GTPA has a mandate and strategy for communicating decision-relevant information, advices, and recommendations specifically to the rural community. It also makes field trips to assess the situation on the ground. The GTPA meets regularly from May to October, and analyzes the agroclimatic and other information prepared by Meteo Mali and other GTPA members, and issues appropriate advice and recommendations. These recommendations and advice address some specific questions that include:

- What is the optimal sowing period that will maximize production and minimize climate risks such as drought during the growing season?

- What is the best time for weeding?
- What is the best time for fertilizer application?
- Given the progress of the rainfall season so far, what are the most suitable crop varieties?

The advice and recommendations issued are based on the different products described in below, and are related to the different aspects of the agricultural activities: land preparation, sowing, weeding, fertilizer and pesticide applications, and harvest:

- The climatological crop calendar is intended to help farmers for planning the different farming activities;
- The climatological sowing dates, daily rainfall measurements, water balance computations, and daily weather forecasts help to recommend optimal dates for land preparation and sowing;
- Daily weather forecasts and water balance calculations are used to recommend days for different activities on the fields;
- Measurements of rainfall, temperature, and humidity are used for monitoring certain crop diseases; and
- Water balance calculations and weather forecasts could be used for recommending dates for harvest.

The agroclimatic advice is disseminated in different formats and languages:

- Daily weather forecasts of rainfall, temperature, and wind are broadcast three times a week in French and in the different local languages;
- The agroclimatic advice on sowing dates and other relevant farming activities are broadcast once every 10 days in French and the local languages on national radio. These are also disseminated to the rural community by SSB radios and through extension workers; and
- Agrometeorogical bulletins and reports are disseminated at the end of each dekad, month, and year.

The 10-day bulletin contains basic information on past and expected weather, state of crops, water resources, fishery, pasture, and cattle movement. It also provides information and recommendations on how to treat crop disease, manage pastures, care for animals, and navigate agricultural markets. The bulletin is disseminated by radio and television in French and different local languages. In many cases, these bulletins also predict future conditions. Radio broadcasts are considered particularly important because of the rural community's high illiteracy rate. The other strength of this information dissemination scheme is the use of local languages, which makes the information very accessible.

Quantitative seasonal forecasts in three categories (based on the terciles, Figure 5) are converted to qualitative forecasts in two categories (good or bad) before they are disseminated to the rural users. In Mr Koite's words "the forecasts are translated from scientific language to operations language."
The GTPA has been making efforts to reach more and more communities. One of these efforts has been the creation of the local multidisciplinary teams for meteorological assistance (GLAM). These groups complement GTPA, allowing the program to work more closely with farmers. There are now a number of these teams across the country (Figure 6).

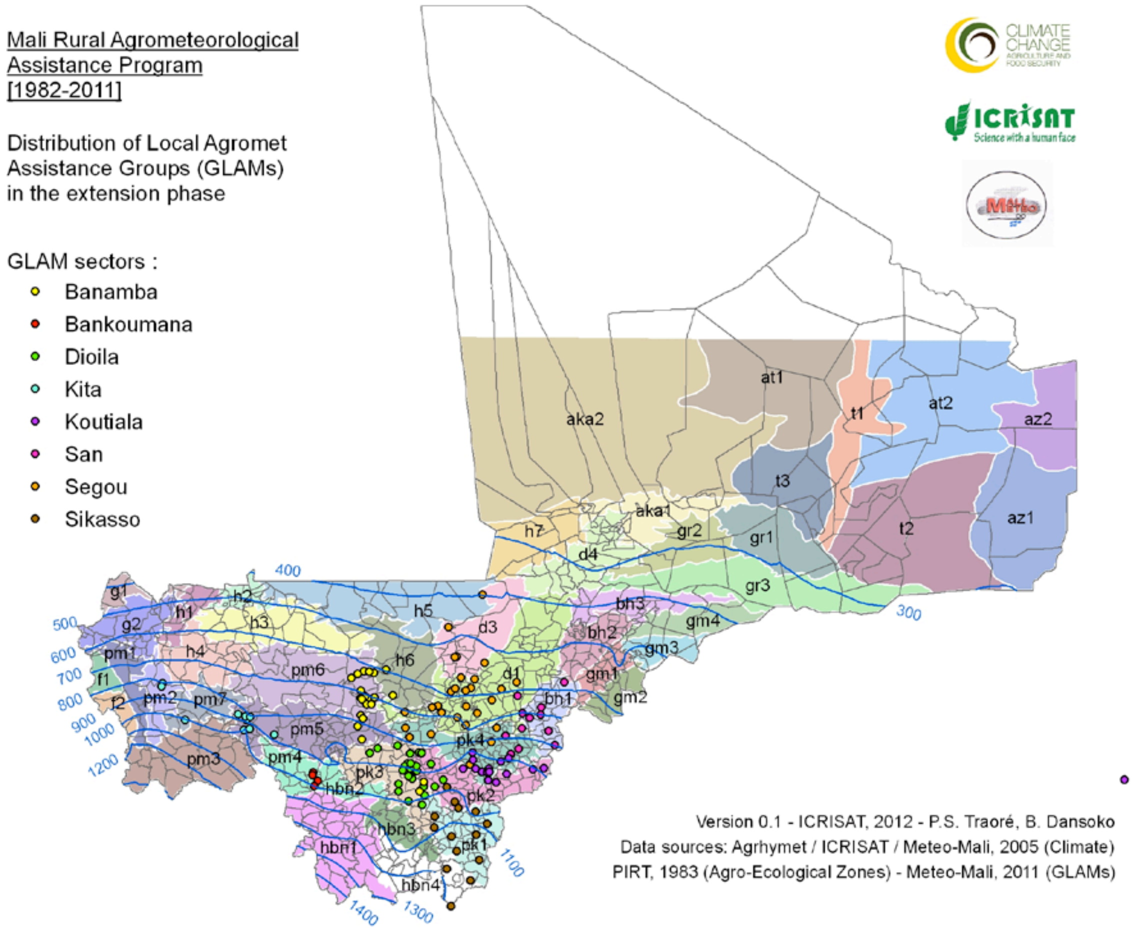


**Figure 6: Distribution of Local Meteorological Support Groups (GLAM). Source: ICRISAT.**

The exchange of data and information between GTPA/Meteo Mali and the rural community occurs in both directions. The overall process of data collection, generation of products, and dissemination of advices and other information is depicted in Figure 7. Agrometeorological data are collected by farmers and extension workers. The data are then sent to Meteo Mali. Meteo Mali and GTPA analyses these data and convert them into useful advice and recommendations, which are sent back to farmers and extension workers for use in the different decision-making processes in the field.

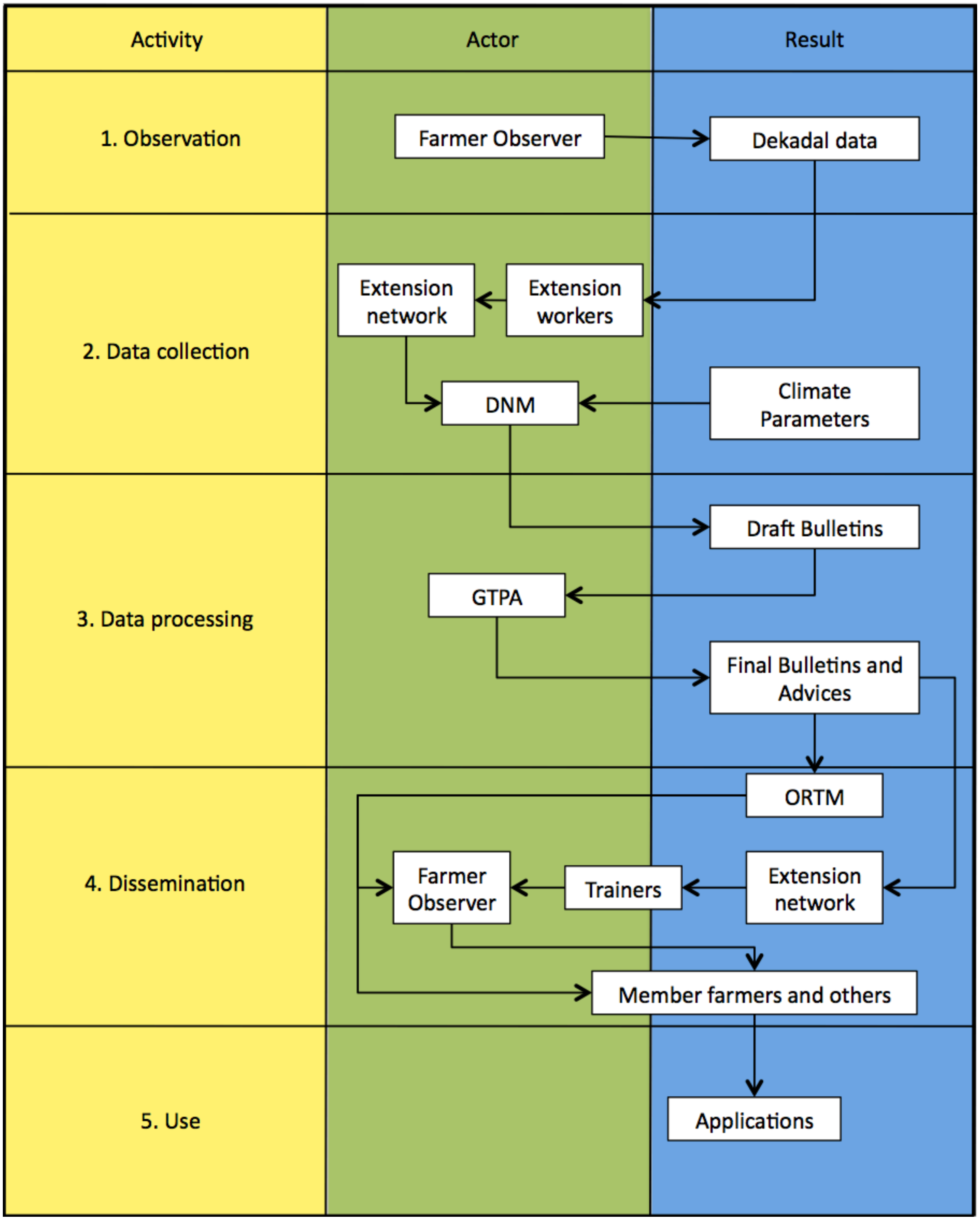


**Figure 7: Schematics for the flow information among the different actors (adapted from Diarra, 1997).**

#### 3.2.3.1. TRAINING AND AWARENESS RAISING

Different types of training and awareness raising activities have been undertaken by Meteo Mali and GTPA. These include training of extension workers and literate farmers on rainfall recording and different aspects of agrometeorology, and awareness raising for the media and decision-makers at different levels. Farmers were given gauges and training to measure rainfall in their fields and were also trained in how to use the rainfall measurements to help them make better decisions on sowing dates and other activities, as discussed in Sections 2.2 and 2.3 above. In order to reach more communities the program has begun offering roving seminars for local communities across the country. Lack of sufficient funds and low-levels of literacy in rural Mali have been reported to be the major challenges in expanding these seminars.

The Meteo Mali organized a "Meteo and Media Day" in 1996 to raise the awareness in the media about the program. The event also aimed to improve the media's understanding of what Meteo Mali does more generally. As the media is the main vehicle for disseminating information, this event helped the media to understand and present the information in the language that the people could understand and relate to.

This event was followed in 1998 with an effort to familiarize parliamentarians and other politicians in different aspects of Meteo Mali including:

- What Meteo Mali does and under what condition it operates;
- What resources are available and what more resources are needed; and
- What were the main problems Meteo Mali was experiencing at the time.

Training and awareness-raising was extended to local administrators during 2003–2004. The creation of the GLAM teams was part of this process. GLAM teams are still working in villages, though the exact number of the teams remains unclear.

### 3.2.4. ASSESSMENT OF THE SCIENTIFIC BASIS OF THE INFORMATION PROVIDED

This assessment addresses the following questions:

- Do the different methodologies used, particularly forecasting, follow "standard" practices?
- Are there better methodologies?
- Are there better/more information products that should have been provided?
- What are the prospects for filling the major information gaps identified in Section 5.4?

#### 3.2.4.1. ASSESSMENT OF THE METHODOLOGIES USED

Seasonal prediction models

The predictors used in the multiple regression model for the seasonal forecasts have been extensively researched, but the robustness of this model needs to be tested vigorously, and models other than multiple regression should be considered. The single model approach is contrary to the multi-model philosophy that is favored in the modeling community. While a multi-model approach may be problematic in applications settings, the point is not so much to have multiple forecasts available, but rather to consider multiple predictions when constructing a forecast.

Probabilistic forecasting methods

The contingency table approach used to convert the best-guess regression forecast to a probabilistic approach is an intuitively appealing methodology, making it simple to explain to users, but it has a number of problems: the sampling errors in the probability estimates can be large given realistic sample sizes for seasonal forecasts, and; the probabilities only ever depend on the category of the best-guess forecast, and thus ignore much of the information about the strength of the signal. As a result, such methods are known to result in poor reliability – the probabilities do not give a good indication of the uncertainty in the forecast (Mason & Mimmack, 2002). These problems are likely to be exacerbated in the consensus products of the Regional Climate Outlook Forum, for example, and if there is any significant attempt to set the probabilities subjectively.

While it has not been possible to verify Meteo Mali's seasonal forecasts directly, a thorough verification analysis of the PRESAO forecast products has been conducted (Chidzambwa & Mason, 2008; Mason & Chidzambwa, 2009). Figure 6 shows the spatial variation of one measure of skill, indicating the performance of the forecast system relative to climatology. Much of Mali shows positive skill, especially in the more northern, drier areas, but the skill is weakest in the most populated parts of the country. What Figure 6 does not indicate is that the PRESAO forecasts as a whole show severe biases (probabilities for the below-normal category are consistently too low), and a marked tendency to over-forecast the normal category (the probabilities for this category are consistently too high). Anecdotal evidence suggests that the over-forecasting of the normal category is a form of hedging by the forecasters who understandably want to avoid being seen as issuing a forecast that potentially has large "errors" (for example, a forecast that is interpreted as "above-normal" would verify poorly if below-normal rainfall occurred). The forecast shown in Figure 5 provides a strong suggestion of an ongoing tendency to over-forecast "normal" rainfall. Mason (2012) argues that this tendency to hedge is a product of inappropriate verification procedures and suggests an alternative formulation of the verification problem that would the incentive to hedge.

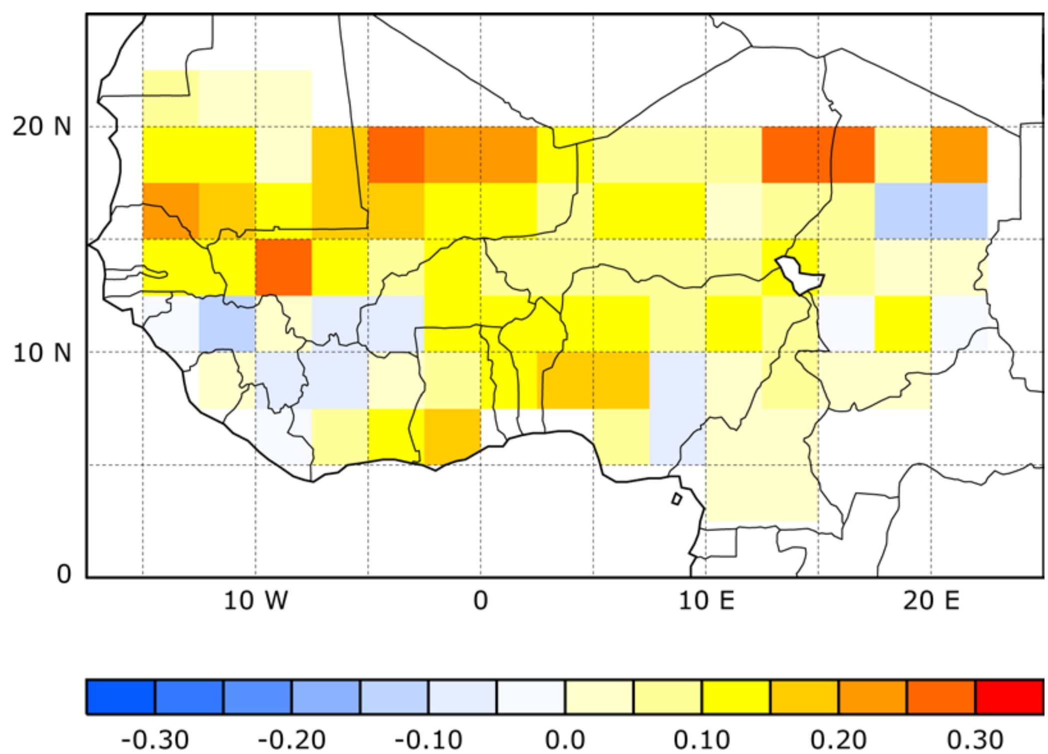


**Figure 8. Map of Rank Probability Skill Scores for the PRESAO July – September forecasts.**

Selection of analogue years

Selecting only the analogue years that are close to the best-guess regression forecast will underestimate the uncertainty in the seasonal total rainfall, and also, inevitably, in the intra-seasonal characteristics.

Translation of forecasts

It is unclear how the Meteo Mali's seasonal forecasts are translated into two-category deterministic forecasts by GTPA. Implying the most likely binary category from the forecast probabilities should be reasonably straightforward if the categories are defined by the median, but the problem is not so trivial if the two categories are defined by the average. It would be very difficult to come up with a reliable estimate of the uncertainty in the forecast, especially given that the tercile-based probabilities are unlikely to be very reliable to start with.

#### 3.2.4.2. ALTERNATIVE METHODOLOGIES

Seasonal prediction models

Although the predictors used to produce the empirical seasonal rainfall forecasts are well-established scientifically, there are opportunities to potentially improve upon this essentially single-model approach. Firstly, alternative statistical models could be considered, such as principal components regression and canonical correlation analysis (Mason & Baddour, 2008), both of which are available in the IRI's Climate Predictability Tool (CPT). Similarly, options to downscale seasonal predictions from outputs of the WMO Global Producing Centres (GPC) should be explored. Using CPT for both the empirical prediction methods and downscaling could enable more locally specific predictions to be made.

Probabilistic forecasting methods

The CPT can also be used to improve upon the estimation of forecast probabilities. The CPT uses a method based on prediction intervals rather than contingency tables, and allows for flexibility in defining the categories and in expressing the forecast uncertainty in different ways, while retaining consistency between all these different options for formatting and tailoring a forecast.

Selection of analogue years

Although some research has been conducted on analogue year selection (Mason & Baddour, 2008), these procedures are not in wide use because of problems with anchoring (Nicholls, 2001). However, if a selection of analogue years is required, rather than having them all clustered around the best guess forecast, a more reliable sample of the uncertainty in the forecast could be generated from the ensemble forecasting option of CPT, which produces a suite of predictions evenly drawn from the forecast distribution. Analogue years could be selected as those close to the individual ensemble members.

Translation of forecasts

The Meteo Mali may wish to discuss with GTPA different options for presenting the forecast, including as a binary forecast, as currently done, without having to compromise the standard tercile-based forecast product. It may also be worth exploring the idea of prediction intervals or probabilities of exceedance (Mason & Baddour, 2008). The tailoring options of CPT make all these options possible.

#### 3.2.4.3. ALTERNATIVE/ADDITIONAL PRODUCTS

Verification information

It is general good practice to work on the principle that forecast information should only be provided if accompanying verification is available. The availability of verification provides a level of transparency in communicating the quality of the forecasts, and may assist users to identify optimal decision strategies. In fact, there are very few meteorological forecasting centers anywhere in the world that provide readily accessible verification information, and so there is an opportunity for Meteo Mali to present a leading example at least to the rest of West Africa, if not beyond. Verification information should be made available for forecasts at all lead-times.

Downscaled information

Empirical evidence from Senegal indicates that a lack of spatial coherence of rainfall intensities contributes to high sampling error and high spatial variability of estimates of seasonal forecast skill downscaled to individual stations (Moron, Robertson, & Ward, 2006). A robust estimate of downscaled forecast skill and potential forecast value would therefore need to evaluate a large set of stations. Presenting the forecasts as zonal averages may well result in increased skill, but then it should then be understood that the forecasts are only valid at this scale, and thus may be useful for national planning, for example, but are unlikely to be useful to individual smallholder farmers.

Forecasts of rainfall frequency

Skill has been demonstrated in the prediction of seasonal rainfall frequency (Robertson, Moron, & Swarinoto, 2009). While such products do not constitute the detailed information on dry-spells that the agricultural community has requested, they are likely to prove of some value. The use of such information should be explored with GTPA.

#### 3.2.4.4. PROSPECTS FOR FILLING GAPS

Prospects for predicting onset and cessation dates

Despite the importance of predicting onset and cessation dates for realizing value in seasonal forecasts (Roudier et al., 2012), this problem has met with only minimal progress. However, there are many decision-making options around the onset date that could benefit from shorter-range forecasts than seasonal, and these should be explored against skill levels that can be provided in extended-range weather predictions. Similarly decisions based on expected cessation dates should be classified based on their time sensitivity, and Meteo Mali should work with GTPA to identify those decision options that can be realistically informed by forecasting capabilities.

Prospects for downscaling

There may be some potential to provide locally-specific seasonal forecast information. At the least, it should be possible to provide specific indications of the skill of the information at local levels. Given the highly localized nature of rainfall in the region, this assessment should be carried out with the maximum amount of available data, perhaps supplemented by merging satellite- and ground-based station data.

In general, verification information could be made available at most timescales in reasonably short order, as discussed in the recommendations in Section 4.1 below.

Prospects for monthly forecasts

The skill of monthly forecasts is currently very limited, but is an active area of research, and has seen improvements as global models increase their ability to reproduce some of the important mechanisms involved at this timescale. However, the level of detail and accuracy required in order to inform any meaningful decision should be identified before any effort is expended in this area.

Prospects for improved guidance

Because of the low skill of seasonal forecasts, it is important to consider a wide range of decision options to avoid underestimating potential forecast value (Hansen, Mishra, Rao, Indeje, & Ngugi, 2009). Profit-maximizing use of seasonal forecasts in semi-arid areas could increase exposure to climate risk, and so it is important to identify appropriate recommendations based on the climate information that can be provided.

### 3.2.5. CONCLUSIONS

The results of this long-term program indicate that the regular provision of agrometeorological information helps farmers manage the risks associated with increased climate variability. The program has successfully built a framework for gathering, analyzing, processing, and disseminating information that farmers can use. A particularly important role has been played by the program's multidisciplinary working group, which has served as a boundary institution by "translating" climate data into practical advice (Hansen, 2002). Such institutional support is essential for the development of smallholder agriculture (Hounkonnou et al., 2012).

However, important questions remain about the details of how useful the different types of information provided have been in improving decisions. It seems that most of the benefit has arisen from the use of the daily to 10-day bulletins, which are translated into advice and recommendations. The seasonal information on the other hand, seems to remain largely untranslated, and is of unknown quality. Preliminary evidence, based on a verification of the PRESAO forecast products suggest that the skill of the seasonal forecasts is positive, but limited, and adversely affected by some systematic errors in the way the probabilities are derived. These problems can be addressed relatively easily, but the issue of translating reliable seasonal forecasts into good advice for smallholder farmers needs to be considered. This research will need to be undertaken, and should be conducted through partnership between the agricultural and meteorological communities because, ultimately, it is the working partnership that has been a key ingredient in the success of the program.

## 3.3. FIELD ASSESSMENT

*EDWARD R. CARR, UNIVERSITY OF SOUTH CAROLINA WITH KALIFA TRAORE, INSTITUT D'ECONOMIE RURAL; LASSANA TOURE, INSTITUT D'ECONOMIE RURAL; TSHIBANGU KALALA, UNIVERSITY OF SOUTH CAROLINA; KWAME OWUSU-DAAKU, UNIVERSITY OF SOUTH CAROLINA*

The field assessment sought to identify and measure the on-the-ground impacts of the Agrometeorological Advisory Program. Initial consultations with Meteo Mali revealed that there had been no independent evaluations of farm-level program impact since the pilot in the early 1980s. Further, the program did not collect baseline data in new participating villages during scale-up. Program interventions had shown promise at the pilot stage, and the impacts of extreme precipitation stress on the main agricultural regions of the country (Figure 9) provided the impetus for rapid scale-up. Therefore this program is best understood as a humanitarian intervention, not a development program or pilot project. The criteria used to select villages for scale-up are not clear, and while Meteo Mali claims there are more than 700 villages participating in the program, there does not appear to be a comprehensive list of these villages.

### 3.3.1. FIELD ASSESSMENT DESIGN

The absence of previous assessments, baselines, and complete lists of participating communities presented significant challenges to the assessment design, forcing the adoption of a post-hoc methodology. The absence of baselines excluded a before-and-after treatment assessment of impact in particular villages. However, given the elapsed time between the treatment and the assessment, it is unlikely that baseline data would have been of use. In most cases, more than two decades had elapsed between treatment and assessment, making it likely that other changes, including the recovery of annual rainfall over the past two decades, changing extension practices, changing availability of inputs, and the fact that a contemporary assessment would likely be examining practices of a different set of farmers than had received the initial intervention, would confound efforts to attribute particular impacts to program interventions.

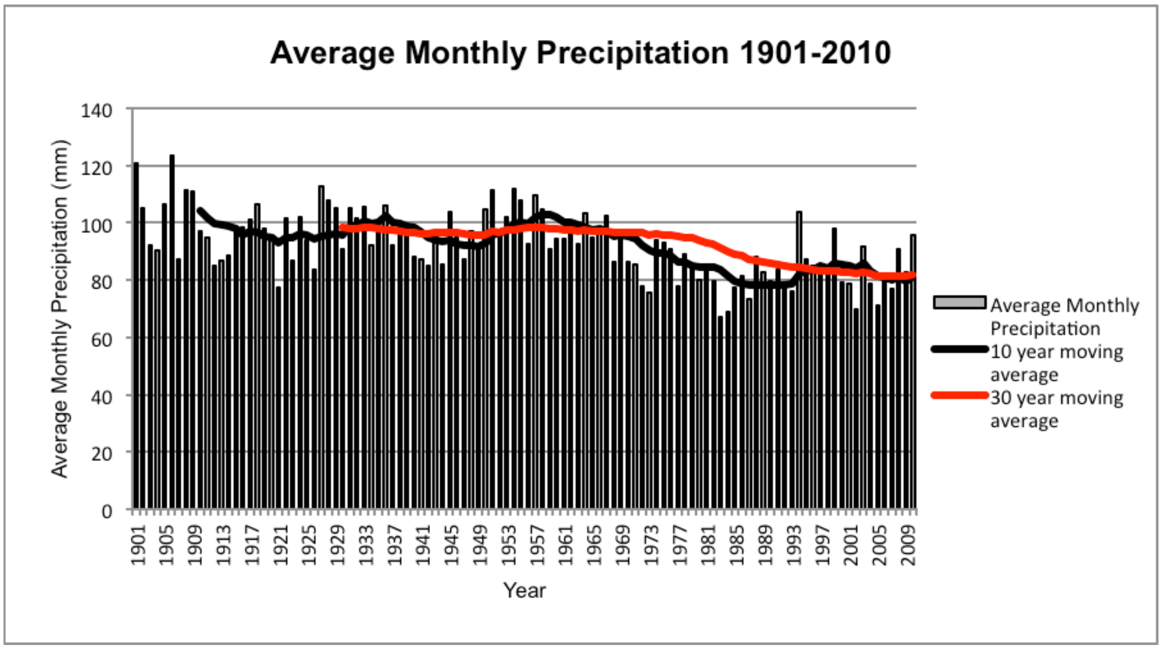


**Figure 9: Average monthly precipitation across Kayes, Koulikoro, Segou, and Sikasso in Mali from 1901-2010. The 10-year moving average trend shows short-term patterns in precipitation, while the 30-year moving average suggests an overall shift in the climate regime to precipitation levels about 83% those pre-1960 (Source: mean WCRP GCOS GPCC FDP version6 0p5 prcp, accessed at http://iridl.ldeo.columbia.edu/expert/SOURCES/.WCRP/.GCOS/.GPCC/.FDP/.version6/.0p5/.prcp/T/12/0.0/runningAverage/T/12/STEP/Y/%2814%29%2810%29RANGEEDGES/X/%28-12%29%28-4%29RANGEEDGES%5BX/Y%5Daverage/figviewer.html?plottype=line&my.help=more+options on 6 June 2013).**

The assessment therefore adopted a second-best approach, identifying 18 villages known to have received Agrometeorological Program-related interventions across its life. These villages (the treatment group) were spread across the regions of Kayes, Koulikoro, Segou, and Sikasso to capture a range of agroecological and climatological situations. Each of these villages was paired with another of similar size, located between 10 and 20 kilometers away, that had never participated in the program, providing a total sample of 36 villages. This second set of villages provided a loose control group for the intervention villages, close enough to control for agroecological and climatological variation without allowing for the easy movement of people between villages, thus limiting the flow of program-related information from treatment communities into control communities.

The specific methods adopted by the assessment were shaped by three major factors: the recognition that in each community different people would be conducting different livelihoods activities, and therefore likely experience different effects from the program; the absence of information about the livelihoods and lives of those living in both the Agrometeorologial Program villages and the control villages; and the desire to move quickly, with limited human resources, to inform the potential programming of USAID climate change funds. Studies in other African contexts have demonstrated that the failure to identify and account for differences in livelihoods and other responsibilities within communities (and households) can result in analyses that over-aggregate the data, making it difficult to capture the real range of activities and vulnerabilities at play (Carr, 2008a, 2008b, 2013). Thus, the field assessment sought to understand intra-community livelihoods dynamics in both participating and control villages before comparing participating villages to controls to seek impact. In this manner, the assessment would be able to compare the different impacts of the program within and across contexts.

Informed by the literature on Bambara livelihoods and kinship, and applying expert judgment, the field assessment team chose to gather data in four cohorts based on gender and seniority (Figure 10) *within* which we expected to see broadly consistent activities, and between which we expected to identify differences in program impacts. The Bambara operate under what Becker (1990, p.315) calls a patrilineal gerontocracy, where the most senior male member of a lineage, which in smaller villages may be the village chief, apportions the land of the lineage to the different households of the men of that lineage. Women cannot own land, but can obtain land for cropping from their husbands, from their husbands' lineages, or other lineages in the community (Akeredolu, Asinobi, & Ilesanmi, 2007). Because they do not own land, women have very insecure land tenure. This prevents them from improving fields, planting long-term crops such as tree crops, and may push them to raise fast-maturing crops lest the landowners re-appropriate the land and crops before the harvest (Akeredolu et al., 2007; Grigsby, 1996).[2]

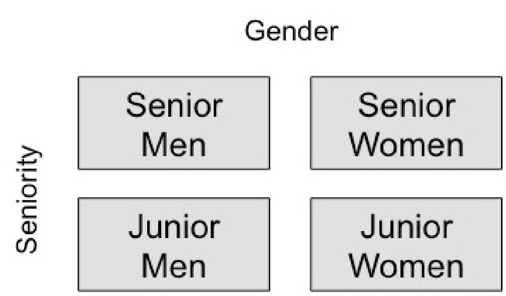


**Figure 10: The social cleavages used to shape focus groups and interviews during the field assessment. These are the cohort groups referred to above and below.**

To understand how the agrometeorological advisories might have impacted agricultural practice and individual, household, and community well-being required an understanding of the vulnerability context

[2] This land tenure system likely influences women's selection of both crops and varieties, regardless of exposure to the interventions of the agrometeorological advisory program.

in which the users of these advisories live. The vulnerability context includes the various economic, environmental, social, and political trends that might affect local livelihoods, the shocks that might occur in each of these realms, and the seasonality of the local environment and economy. The best available information came from the Famine Early Warning System's livelihoods zoning and profiling report (Dixon & Holt, 2010), but this study lumped all residents of a given livelihoods zone together. This presentation of challenges assumes a unified vulnerability context for residents of a given zone. The field assessment team addressed the issue of livelihoods challenges and hazards in its focus groups, obtaining not only different challenges, but also different prioritizations of the same challenges within villages, depending on both the gender and seniority of those participating in the focus group. Further, those living in villages with a *Groupe Locaux d'Assistance Météorologique* (Local Meteorological Support Group, henceforth GLAM) often experienced challenges differently than those in former GLAM villages and control villages, and at times experienced entirely different challenges. For example in cluster 1 senior men in GLAM villages ranked access to land as their only challenge, while those in villages that were not participating in the advisory program listed limited access to inputs, irregular/inadequate rainfall, limited access to equipment, and soil degradation ahead of access to land. Lumping all challenges and hazards into broad categories for the cluster homogenizes this diversity, and therefore makes it difficult to identify different vulnerabilities in this cluster. These vulnerabilities are important, as they inform livelihoods decisions and outcomes that shape the utility of the agrometeorological advisories. Fieldwork cast a wide net, effectively conducting a livelihoods survey of each cohort in each village before moving to discussions of weather, climate, and the agrometeorological advisory program.

Finally, working with limited time and resources, the assessment team chose to focus on the identification of behavioral changes or seasonal decisions associated with the agrometeorological advisories. A full assessment of program impact would have required the measurement of farms of each interviewee and the verification of harvest size for each crop on those farms. This would have taken months of fieldwork, and raised the cost of the assessment significantly for an assessment that is not yet clear on whether or not the program does in fact function as described. The assessment team made this decision based on the assumption that if there was no evidence of behavioral change or specific seasonal decisions associated with the provision of the advisories, there was not going to be a measurable impact. However, if the assessment identified behavioral changes or seasonal decisions that were associated with access to the advisories, future work could sub-sample within this population to conduct an impact assessment.

### 3.3.2. FIELD ASSESSMENT PRACTICE

In February and March of 2012, the field assessment conducted 144 focus groups and 720 interviews in the 36 sample communities. Communities were selected from a limited list of communities participating in the program, and paired with a nearby community of similar characteristics that was not participating, in an effort to build a weak treatment-control comparison. The field assessment followed the same protocol in all villages. Two teams of four investigators (each comprised of two men and two women) arrived at a given pairing of treatment and control villages at the same time, with one team going to each village. Each assessment team started by conducting a general village meeting with the traditional leadership, usually facilitated by the local agricultural extension agent. The village meeting introduced the team to the community, and explained the investigation as a broad effort to identify the challenges and opportunities in each community. In each village, the role of climate variability and change as either opportunity or challenge was not known. Therefore, one goal of the teams was to assess the relative importance of these issues in each community to help contextualize the importance and impact of the agrometeorological program to community members. To avoid preconditioning the responses of community members, the teams expressly avoided mentioning weather or climate in village meetings.

After the initial meeting, the team asked for community representatives to participate in focus groups. The groups were divided by gender and seniority as illustrated in Figure 10. Each community defined junior and senior for itself, as the assessment team recognized that these categories were not tied to absolute ages as much as social status derived from marital status, income, livelihoods activities, landholding, and other considerations. As a result, the division between junior and senior varied across the sample villages, ranging between 35 and 45 years. The women in the assessment team led women's focus groups, while the men from the team led men's groups. The focus groups followed a broad guide (Appendix 1) intended to bring out general information on the vulnerability context of each cohort (recognizing that a challenge for one group might be irrelevant, or an opportunity for another), and the livelihoods of that group, especially agricultural practice (as this is the livelihoods activity targeted by the agrometeorological program). This guide was field-tested and revised twice by the assessment team before being used in the sample villages. The focus group guides did not mention weather or climate issues, ensuring that responses about these issues were driven by the concerns of the group and not an effort to provide answers desired by the assessment team.

On the second day of the assessment exercise in each village, the team conducted individual interviews, typically with between five and six members of each age/seniority cohort. The individual responsible for the focus group of a given cohort also conducted the interviews associated with that cohort to better identify moments of contradiction and coherence between focus group responses and individual responses. The interviewees included two or three members of the focus group, with the balance comprised of individuals who did not participate in the focus group. This partial overlap allowed for a level of rigor in the data collection by providing cross-checks for consistency between the responses of focus groups and individual community members. By including interviewees from outside the focus group in each cohort, the team also gained a measure of understanding of the wider representativeness of the focus group and interview responses, especially where these responses were consistent across all sources. Finally, triangulating responses across interviews, focus groups, the existing literature on Bambara livelihoods, and local weather and climate data allowed for a degree of validation of both focus group and interview responses.

The interviews followed a second guide document (Appendix 2) that, like the focus group guide, was field tested and revised twice before being used in the field. This guide went into greater individual detail with regard to livelihoods, including changes in agricultural practice over time, and asked specific questions about decisions and activities in the 2011 agricultural season. As with the focus groups, the assessment teams did not initially mention weather and climate unless the interviewee raised them as issues first. If the interviewee did not raise weather, climate, or the agrometeorological program by the end of the interview, the interviewer then asked a series of direct questions about the program and its actual or potential impact on the interviewee.

### 3.3.3. DATA ANALYSIS

Because the villages span four administrative regions and a range of agroecological zones, there is little utility in analyzing it as a whole. Different crops, with different agroecological requirements, were grown under different weather and climate conditions across this sample. Pairwise analysis was complicated by two factors. First, the team found that several villages once part of the agrometeorological program were no longer participating, usually because the rain gauge had been broken or because the observer farmer assigned to that rain gauge had died or otherwise moved. These villages constituted a useful sub-grouping within the dataset. Those in former GLAM villages no longer have access to the advisories that might inform seasonal decisions. However, they experienced extended exposure to the advisories that might have shaped patterns of behavior with regard to agricultural decisions. The presence of this third grouping of villages provided an opportunity to disaggregate seasonal decisions from long-term behavioral changes associated with the program. Pairwise comparison also made little sense because as the sample sizes being compared were extremely small (typically n=5 or 6), making it difficult to achieve generalizable, rigorous statements about differences in behavior across GLAM and non-participating villages.

As different crops have different ecological requirements, the team hypothesized that those villages with the most similar crop emphases would likely share similar patterns of impact from participation in the program. Therefore, team members from the University of South Carolina clustered the villages into meaningful groups based upon village-level similarities/differences between the crops and livelihoods emphasized by residents (for details on the clustering techniques used, see Appendix 2).

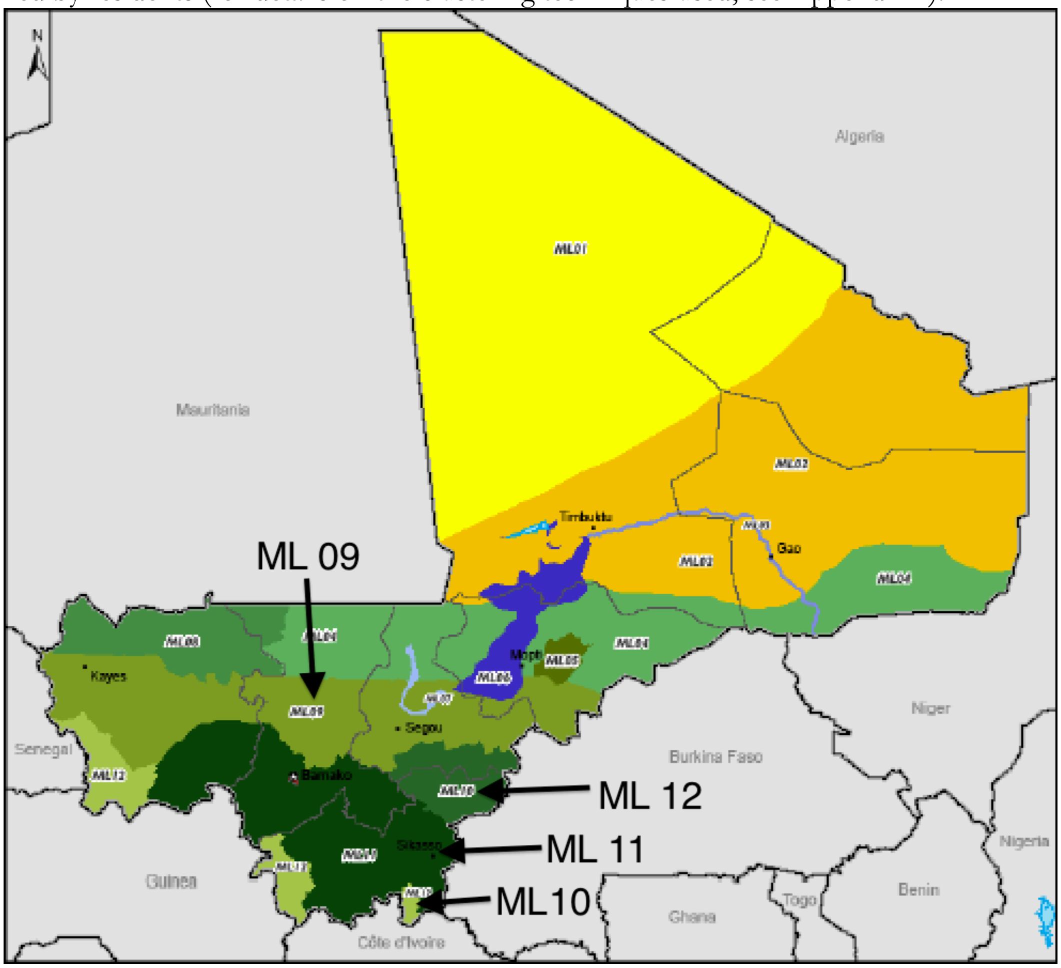


**Figure 11: Livelihood zones in Mali, with the four livelihoods zones represented in this assessment highlighted. Note that the assessment only looked at villages in the specific part of ML 10 identified in this figure (from Dixon & Holt, 2010:12).**

The clustering exercise resulted in four clear groupings which coincided with four of FEWS-NET's livelihood zones in Mali (see Dixon & Holt, 2010) (Figure 11). The first cluster of nine villages (one GLAM, five controls, three former GLAM) aligned with FEWS-NET's ML09 "West and central rainfed millet/sorghum" zone. Cluster 2 is made up of five villages (two GLAM, two control, one former GLAM) which, while apparently located in ML11 ("South maize, cotton, and fruits"), appear to be better defined as northern extensions of FEWS-NET's ML12 "South-west maize, sorghum, and fruits" zone. Cluster 3, comprised of six villages (three GLAM, one control, two former GLAM), aligned with the center and western portions of FEWS-NET's ML11 "South maize, cotton, and fruits" zone. Cluster four includes thirteen villages (four GLAM, seven control, one former GLAM). This cluster was not easily distinguished from the third cluster in the initial clustering exercise. However, the University of South Carolina team applied expert judgment and the FEWS-NET zoning to suggest that this fourth cluster geographically fit the ML10 "Sorghum, millet, and cotton" zone. Each cluster is marked by "a fuzzy edge" between them, where different clusters of villages/livelihoods zones shade into one another. Thus, some of the villages in the second cluster (ML11) are spatially very proximate, if not overlapping, with some villages in the fourth cluster (ML10). It is also worth noting that the clustering exercise resulted in the exclusion of three villages from analysis. Two villages clustered together (and clearly not with any other cluster), but they were so spatially distant from one another that the assessment team felt uncomfortable drawing conclusions from them. The third village was excluded because its status as a participating or non-participating village in the program could not be adequately determined from the responses of the residents.

The analysis of the data summarized below, and presented at length in the field data annex to this report, is largely qualitative. Within clusters the sample sizes for each cohort within each village type often fell to very low levels (i.e., 5), and while p-tests were conducted to look for significant differences in the crop and variety selections between the members of these cohorts, the likely reliability of those tests is very low and adds little to the assessment. When analyzing variety selection the field team focused analysis on cycle length, as this is the only variety characteristic used by the advisories when providing recommendations. Therefore, different varieties of the same cycle length were grouped for the purposes of analysis. While varieties also have other characteristics that shape farmer selection, these are characteristics that have less to do with the information provided by advisories and more with local soil and other conditions.

For each cluster, analysis compares cohorts within control, GLAM, and former GLAM villages, as well as across the different types of village. For example, the analysis considered the differences between junior men and senior men within GLAM communities in a given cluster, while also looking at the differences between junior men in GLAM villages, former GLAM villages, and control villages to look for different practices that might influence program impact within treatment villages, as well as any significant relationships between participation in the program and changed livelihoods practices that might reflect program impacts. It is critical to note that this analysis is limited to the identification of relationships between program participation and particular livelihoods activities and decisions. When such relationships can be triangulated with information on program use and livelihoods, we can build a strong circumstantial case around particular explanations for observed patterns of decision-making. However, the explanation of these relationships is not always clear from the data at hand, and will require additional investigation, an issue raised at the end of this assessment.

### 3.3.4. FINDINGS

For the 2011 agricultural season, the field assessment found little clear evidence for the impact of the advisories on agricultural decision-making at the level of crop selection in the four clusters of villages in the four livelihoods zones covered. However, there is strong evidence for the impact of these advisories on variety selection among the subset of farmers in GLAM villages who were using the advisories.

#### 3.3.4.1. USE OF THE ADVISORIES

Self-reported use of the advisories varied widely in the clusters analyzed in this assessment. Further, it varied by the cohort assessed. Figure 12 summarizes the statistics on advisory use. Awareness of the program varied widely, depending on the cluster assessed. In (West and Central Rainfed Millet/Sorghum zone), all interviewees in the GLAM village were aware of the program. In cluster 2 (South-west Maize, Sorghum, and Fruits zone), no more than 44% of any cohort was aware of the program. As the advisory program has existed for some time in all of these villages, this is a particularly surprising finding. In general, men were more aware of the program than women, and where there were differences, junior men were more aware of the program than senior men.

**Cluster 1**

| | Aware of program | Follow advice | % likely using |
|---|---|---|---|
| GLAM senior men | 100.00% | 80.00% | 80.00% |
| GLAM senior women | 100.00% | 0.00% | 0.00% |
| GLAM junior men | 100.00% | 80.00% | 60.00% |
| GLAM junior women | 100.00% | 0.00% | 0.00% |

**Cluster 3**

| | Aware of program | Follow advice | % likely using |
|---|---|---|---|
| GLAM senior men | 66.67% | 46.67% | 9.52% |
| GLAM senior women | 53.33% | 33.33% | 17.78% |
| GLAM junior men | 93.33% | 60.00% | 17.28% |
| GLAM junior women | 73.33% | 33.33% | 9.78% |

**Cluster 2**

| | Aware of program | Follow advice | % likely using |
|---|---|---|---|
| GLAM senior men | 33.33% | 33.33% | 13.89% |
| GLAM senior women | 30.00% | 0.00% | 0.00% |
| GLAM junior men | 44.44% | 22.22% | 12.35% |
| GLAM junior women | 20.00% | 10.00% | 0.00% |

**Cluster 4**

| | Aware of program | Follow advice | % likely using |
|---|---|---|---|
| GLAM senior men | 65.00% | 45.00% | 16.25% |
| GLAM senior women | 44.44% | 11.11% | 0.00% |
| GLAM junior men | 85.71% | 80.95% | 14.41% |
| GLAM junior women | 25.00% | 25.00% | 6.25% |

**Figure 12: Summary data on the percentage of farmers aware of the GLAM advisories, claiming to use the advisories, and those displaying enough knowledge of the advisory program's function to be likely users of the advisories.**

The actual use of the advisories varied widely within and across the assessed villages. *Within villages*, men were far more likely to report following the advisories than women. Junior men were generally the most likely cohort to claim to follow the advisories, while senior women were, on the whole, the least likely to be using the advisories. *Across clusters*, cluster 1 (West and Central Rainfed Millet/Sorghum zone) contained the largest percentage of men of both cohorts claiming to use the advisories, followed in descending order by clusters 3, 4, and 2. The largest percentage of women in both cohorts claiming to use the advisories was in cluster 3 (South Maize, Cotton, and Fruits zone), followed in descending order by clusters 4, 2, and 1, where no women claimed to use the advisories.

These differences in rates of claimed use should not be interpreted as different levels of confidence in the advisories. The importance of GLAM crops (cotton, maize, millet, sorghum, and peanuts) within both agricultural and livelihoods strategies varied across the clusters, thus making them more or less useful. Further, the *use* (e.g., sale or consumption) of the crops grown varied across the clusters. The varying use of crops across clusters is a critical finding, as the assessment has anecdotal evidence that farmers likely select varieties of popular staple crops such as peanuts, when seen as principally for market sale, for the purpose of timing harvests at maximum prices, near the end of the hungry season. Such decisions dictate the selection of varieties without regard for advisories. On the other hand, when such staples were principally grown for subsistence, different variety selections seemed to go into effect, potentially suggesting that in those situations farmers might have used the advisories to inform variety selection.

Finally, women's infrequent claims for the use of advisories were also tied to non-climate factors. First, women generally planted far fewer GLAM crops than men, and in many cases (hand irrigated) gardened crops were major components of their agricultural practice. For such women, the advisories likely had far less utility than for a man who was focused on the cultivation of all five GLAM crops, and who lacked access to adequate irrigation. Second, there is evidence to suggest that women in all clusters had limited ability to make their own variety selections, as women's selections closely align with those of the men in their clusters. Third, it is not clear that women could act on the advisories if they had the autonomy to make their own seed selections, as agricultural practice (at least in some clusters) appears to focus the households' labor on the man's farm first, before shifting to women's farms[3]. In such situations, women's planting might be delayed several days by the need to plant men's farms first, thus greatly limiting the utility of the advisories. It is worth noting that in cluster 3 (South Maize, Cotton, and Fruits zone), 27% of senior women and 7% of junior women argued that the advisories were only for men. In cluster 4 (Sorghum, Millet, and Cotton zone), 28% of senior women and 30% of junior women made the same claim. As this was not a specific question on the interview form, it is likely that the number of women holding this view, at least in these clusters, is higher than this rate of reporting, further reinforcing the idea that women have limited access to the advisories, and limited capacity to act on the advisories when delivered.

In summary, the variable rates of claimed use of the advisories likely reflect a combination of cluster-specific agricultural factors, gender- and seniority-specific agricultural roles, and *possibly* varying degrees of confidence in the advisories. The assessment of confidence in the advisories cannot be made rigorously from the data at hand.

The likely real rates of use of the advisories were extremely low in most clusters and cohorts. For the purposes of this assessment, those likely to be using the advisories were those that claimed to use them and, in the course of the interview, demonstrated some level of working knowledge of the program (i.e., the role of the farmer observer, the transmission of information, etc.) when asked about it specifically. The highest rates of use were among men in cluster 1 (West and Central Rainfed Millet/Sorghum zone), though it must be noted that these results come from a single GLAM village, and therefore may be distorted by the experiences of that village. All other clusters contained two or more GLAM villages. However, in all other clusters the rates of use by men were substantially lower than in cluster 1, with no male cohort above 20%, and most below 15%, suggesting that even with a second GLAM village in cluster 1 the rate of response would have been different. Among women, the highest rates of use were in cluster 3 (South Maize, Cotton, and Fruits zone), but it must be noted that the highest of these, senior women in cluster 3, was below 20%. It did not appear that any women were using the advisories in clusters 1 and 2, and none of the senior women in cluster 4 (Sorghum, Millet, and Cotton zone). Across all cohorts except the men of cluster 1, the rates of use are extremely low. While the evidence at hand does not explain this pattern, it appears that the rates of use are highest in the zone where the skill of forecasts is highest, and where annual rainfall is lowest, making the advisories both useful and needed. Further, the low rates of use may reflect gradients of wealth in the GLAM villages, where men in the

[3] All of these factors conform with general understandings of agricultural decision-making in southern Mali. See (Rubin & Me-Nsope, 2011)

wealthiest quintile are those with the decision-making role at the level of the household (*gua*) and the access to farming equipment and financial resources necessary to act on advisories in a timely manner.

#### 3.3.4.2. EVIDENCE FOR THE IMPACT OF ADVISORIES ON CROP SELECTION

Seasonal forecasts and advisories could have utility for farmers planning the composition of their farms in the upcoming season. However, the advisories do not provide specific advisories on what crops to plant (as opposed to what *varieties* to plant – see below). Therefore, it is perhaps of little surprise that there was little clear evidence for the advisories' impact on crop selection. In clusters where there appeared to be a difference in the crop selections of those with advisories and those without, there were often confounding factors that were as likely to produce the observed differences. For example, in cluster 1 those in GLAM villages appeared to de-emphasize millet on their farms in favor of sorghum. However, those in GLAM villages owned more livestock, and their focus on sorghum may reflect a need for fodder, as opposed to a seasonal decision based on the advisories. Further, in each cluster, when we compare the crop selections of those using the advisories *within* GLAM villages with other members of their cohort who are not using the advisories in those villages, there were no clear differences where we would expect similar patterns of selection. It is therefore unlikely the advisories play a significant role in crop selection for those who are using them.

The lack of impact on women's crop selection is likely the product of gender/seniority roles in agriculture, as opposed to a lack of utility or confidence. In a slight majority of cases, no women in a given cohort were using the advisories at all, and therefore the program clearly had no impact on their crop selections. However, it is worth noting that women of all cohorts, in all clusters, grew far fewer GLAM crops than men. In some cases, this was the result of a greater focus on irrigated gardening or rice production. In these cases, there are no advisories for these crops, and therefore the advisories are not informing these crop selections. For those women who are growing GLAM crops, it is not clear that they are independently deciding what to plant, or if they are influenced or controlled by their husbands or (in the case of widows) their sons. Therefore, the *potential* impact of the advisories on women's crop selection is extremely low in the program's current form.

#### 3.3.4.3. EVIDENCE FOR THE IMPACT OF ADVISORIES ON VARIETY SELECTION

There is clear evidence, in all four clusters, for the use of advisories in variety selection. The advisories generally reduce the recommended cycle length of varieties as the recommended planting date moves further into the season, making variety selection a proxy for using the advisories to time the planting of crops as well. In all four clusters, men's variety selections largely conformed to expected selections given the advisories and local precipitation conditions. The different selection outcomes in clusters 2, 3, and 4 strongly support this interpretation. While all three clusters received the same advisories with regard to the timing of planting and the varieties to plant, they did not receive the same amounts of rain at the same times. The differences between these clusters are consistent with the use of local rain gauges to calibrate the advice in the advisories to local conditions. However, *within clusters* these selections did not always result in materially different patterns of selection between those using the advisories and those without access to them. It is unclear if this is because the 2011 season performed in a manner that, at least for some crops, led to a convergence between the variety selections promoted by the advisories and the selections that other farmers were using in the area.

It is important to note that the expected use of the crop in question is critical to interpreting variety selection. The assessment team gathered anecdotal evidence suggesting that some (usually wealthier) farmers try to time the harvest of at least one staple crop so that they can sell that crop during hungry season, when prices are the highest. As a result, these farmers are selecting short-cycle varieties regardless of seasonal forecasts and advisories, as they are trying to time the market, not the natural environment. This appears to be the pattern among senior men in clusters 3 (South Maize, Cotton, and Fruits zone) and 4, and junior men in cluster 3, where farmers in GLAM villages, and those using advisories, appeared to be planting the same or longer-cycle varieties of key staples like millet, maize, and sorghum, while planting shorter cycles of peanuts. This contradictory trend makes sense because, in these cases, these men see peanuts as being at least in part for sale, while the other crops are typically subsistence staples for which they want to maximize total yield, rather than time a market. However, this is only one part of a complex calculus, as peanut plants can provide fodder for livestock once harvested. Short-cycle plants will be harvested during the rains, and therefore are very difficult to store as fodder, while long-cycle plants will often mature and be harvested near the end or after the rains, allowing for storage. Farmers in several of these clusters are likely balancing market and fodder needs in their peanut variety selections. Establishing the exact nature of this balancing will require additional investigation. If borne out this observation is a critical lesson that should influence program adjustment and program design in other settings.

#### 3.3.4.4. ARE THE ADVISORIES ADDRESSING THE NEEDS OF FARMERS?

Producers of climate information and climate services often presume that weather and climate information are inherently useful. The assessment data on livelihoods challenges strongly suggests that this is not a safe assumption, and requires verification before project design and evaluation during program implementation.

In cluster 1, irregular or inadequate rainfall was listed as the first or second most important livelihoods challenge by all cohorts in all villages except senior men in GLAM villages. These men listed almost no challenges of any sort, so it is difficult to determine if these results reflect the quality of the focus group conducted with these men or the unique situation of these men in this village. In general, however, the delivery of seasonal and 10-day advisories speaks to one of the most important challenges in this cluster. Lack of farming equipment and lack of access to inputs were other widely-held challenges in this cluster.

In cluster 2 (South-west Maize, Sorghum, and Fruits zone), the picture is far less clear. Only four cohort/village combinations listed irregular or inadequate rainfall as a livelihoods challenge, though all who mentioned this issue noted it as the first or second most important challenge they faced. It is interesting to note that all men in GLAM villages saw this as their most important problem. These men were reporting the highest rates of GLAM crop cultivation, and therefore much of their agricultural production (which was central to cash income in their livelihoods) was exposed to irregular or inadequate rainfall. More than 1/3 of junior men in control villages were gardening, thus mitigating their exposure to climate variability through hand irrigation. Senior men in control villages were farming a wide range of crops, and while none reported gardening as a livelihoods activity, several of their reported crops are garden crops that were also likely hand irrigated. Instead, in this cluster, there was far greater and more widespread concern for access to adequate farming equipment and inputs. The advisories could speak to these issues if they were appropriately focusing the use of these limited resources, thus ameliorating the challenges of limited access. However, it is not clear that the advisories were delivered in a manner that would meet this need (though they likely could be tweaked to do so, by explicitly focusing on the timing of fertilizer application, etc.). In summary, in cluster 2 it appears that the advisories, insofar as they are focused on precipitation forecasts, had greater utility for a limited subset of farmers than for the inhabitants of the cluster as a whole. That said, if this limited subset of farmers are those with the ability to shape the decisions and practices of others in their households or wider family concessions (*du*), the advisories could have a wider impact than is apparent here. It is also possible that this limited use reflects the limited ability of many farmers to mobilize the equipment and inputs necessary to follow the advisories in a timely manner. A careful consideration of the broad needs of those in this cluster will likely deepen our understanding of this limited uptake, and the broader impact of the advisories (if any) in these communities.

In cluster 3 (South Maize, Cotton, and Fruits zone), concern for irregular/inadequate rainfall was uneven. In most cohorts, across most village types, it ranked among the top two problems. However, for senior men in GLAM villages it rated as a relatively minor problem, and was never mentioned by senior men or junior women in control villages. The lack of concern for climate variability among these cohorts may be related to their high rates of livestock ownership, which might have provided a buffer against inadequate harvests, though this can only be a partial explanation as rates of livestock ownership were high across all cohorts in this cluster. In cluster 3, lack of farming equipment was a challenge on par with that of irregular/inadequate rainfall, while lack of inputs was a challenge listed by everyone except senior men. While it is not clear that the advisories addressed this challenge by making the use of these limited resources more efficient, adjusting the advisories to do so could widen their impact and applicability.

In most cohort/village combinations in cluster 4 (Sorghum, Millet, and Cotton zone), irregular/inadequate rainfall was one of the top two challenges. The only exceptions were senior men and junior women in former GLAM villages.

Lack of inputs and lack of farming equipment were universal challenges in this cluster, on par with that of climate variability. All other concerns varied with in occurrence and importance across the clusters. It is worth noting that in clusters 1 and 3, lack of access to appropriate seeds was a concern raised by many in GLAM villages. While there is not enough evidence to interpret this rigorously, it suggests that many farmers in these clusters faced challenges obtaining their desired seed choices, and therefore their choices of crops and varieties. In these clusters, the lack of strong differentiation between the crop and variety selections of those using the advisories and other farmers may reflect issues of seed availability, not issues related to the utility of the advisories. There is circumstantial evidence at this point for this conclusion, for in clusters 2 (South-west Maize, Sorghum, and Fruits zone) and 4 (Sorghum, Millet, and Cotton zone) there is greater differentiation between the crop and variety selections of those using the advisories and those who are not. In these clusters, farmers either did not mention seed availability as a challenge, or listed it as a minor challenge, suggesting that their variety selections may more accurately represent their desired crop/variety combinations, combinations that were informed by the advisories.

In summary, the advisories as currently designed and delivered do appear to meet a widely-held need in the villages considered in this assessment. However, not everyone appears to need the advisories, as currently presented, equally. While women considered climate variability to be a major challenge in most cohorts, the exposure of their own agricultural production to that variability differed greatly across clusters. In many cases, women were gardening hand-irrigated crops, and therefore their production was somewhat insulated from climate variability (while they were not dependent on rainfall for water, low rainfall could make gathering adequate water for irrigation difficult). In these cases, women may be discussing challenges that impact them via the household economy, which is heavily predicated on men's production. The data does not unequivocally support the idea that these advisories are useful to women *directly*. Further, those living in drier agroclimatic areas, such as in cluster 1, grow fewer GLAM crops overall (generally forgoing maize and cotton), and have livelihoods in which livestock husbandry plays a very significant role. For these communities, households, and individuals, the advisories might provide useful information for a component of their livelihoods, but do little for other important parts of livelihoods, limiting their impact on the overall resilience of these households to climate variability and change.

#### 3.3.4.5. CAN THE FARMERS ACT ON THE ADVISORIES?

A critical question related to the utility of the advisories is the capacity of farmers to act on this information. As discussed above, in clusters 1 and 3 there is evidence to suggest that the farmers receiving the advisories might not have had access to the seeds they needed to modify their agricultural practices in accordance with the climate information they received. Further, several cohorts across the clusters in this study were heavily engaged in livestock husbandry, and may have been constrained in their crop choices by the need to produce both food and fodder, and constrained in their variety selections by the need to provide that fodder at particular times to avoid the loss of animals as household assets. Finally, in several clusters it appears that women's variety selections for GLAM crops are heavily shaped by the selections of their husbands or sons. More research is needed to understand if women in any of these clusters have the right or responsibility to purchase their own seeds, or if they are dependent on the purchases of the male head of the household. Further, in situations where they do have this right or responsibility, we need to determine if their seed choices are influenced by the advisories, the choices and advice of men, or other sources of information.

The ability of farmers to act on these advisories raises an issue of information transmission that arose anecdotally during initial fieldwork in Mali. During a conversation with one of the farmer observers responsible for measuring rainfall in a GLAM village and disseminating the advisories with reference to those measurements, it became clear that he was not directly communicating this information to his fellow farmers. The translated version of his response (from Bambara to English) was "that would be too much." But when asked if he himself used the advisories, he said he did. When asked if other farmers observed his decisions and actions and followed what he did, the farmer observer said yes. Simply put, this farmer observer had developed a socially acceptable means of dealing with probabilistic forecasts. As forecasts will, from time to time, be inaccurate, it is inevitable that there will be times in which members of the community will be misinformed by an advisory and feel upset about this outcome. It is unlikely that these unhappy farmers will travel to Bamako to complain to the Meteorological Service, which makes it likely they would vent their displeasure at the farmer observer. By following the advisories without communicating them to the community, this farmer observer created a situation where people could see what he was doing and choose to follow him, but could not complain that he had misinformed them in the event of a bad forecast. Further research must be conducted into this issue. In a small village of a few hundred people, it is likely that everyone will know when the farmer observer starts planting, and what he starts planting. But in a village of a few thousand, such information will likely be delayed or lost entirely for some in the community, limiting their ability to act on the advisories. End-delivery of the advisories to GLAM communities clearly requires further attention.

#### 3.3.4.6. SUMMARY OF EVIDENCE FOR IMPACT OF THE AGROMETEOROLOGICAL ADVISORY PROGRAM

The initial field assessment of the agrometeorological program's impact presents a picture of uneven patterns of possible impact across clusters and cohorts within clusters, but for farmers that are aware of, have access to, and understand the function of advisories, there is clear evidence of advisory use in their agricultural decisions, principally in the arena of variety selection and the timing of planting (which are very closely related, as cycle length is greatly constrained by how late in the season one plants). In some situations, the factors that the program were meant to influence (i.e., variety selection and the timing of planting) are impacted by a number of confounding factors ranging from seed and equipment availability to the composition of household and individual livelihoods such that the "signal" of evidence for advisory use is attenuated by the "noise" of other factors that shape these decisions.

# 4. RECOMMENDATIONS

*EDWARD R. CARR, UNIVERSITY OF SOUTH CAROLINA AND SIMON MASON, IRI*

Based on the science and field assessments, the team has a number of recommendations for improving the provision of weather and climate information to the Malian agricultural community. However, any effort to implement changes in Meteo Mali's operational production with regard to weather and climate information should adhere to the following principles:

1. The initiative for implementing any changes must come from Meteo Mali itself, which will require that Meteo Mali:
    a. Recognizes any problem in current operational practices (whether they be improvements in the quality of existing practices or opportunities to fill existing gaps) and the need to address the problem;
    b. Accepts a solution that has been demonstrated will improve the quality of existing practices or will fill a gap, and that is not seen as being externally imposed; and
    c. Has the proposed change ratified by the respective manager of operations, or by the Director, where appropriate.
2. Meteo Mali must have the institutional capacity to maintain any change in practice, which will require that:
    a. New procedures are documented in any relevant guides to operational practice; and
    b. Training procedures are in place to ensure that all staff with operational responsibilities are adequately trained so that new procedures are continued in the event of any changes in personnel.
3. Any proposed changes in operational procedures must remain as consistent as possible with those of other Meteorological Services in the region, and with operational procedures endorsed by the World Meteorological Organization and the Global Framework for Climate Services, where relevant, which will require:
    a. Careful coordination with regional and global service providers; and
    b. In some cases, region-wide initiatives to develop operational practices where substantive changes in practice are involved.

This report's recommendations are broken into two parts. The first part reviews findings that the assessment team feels are actionable now, and suggests ways of addressing those findings. The second part discusses the issues and challenges that this report raises, and identifies the means by which we might address these challenges and knowledge gaps to more fully understand the functioning of this program, and help others design effective assessments of other existing climate services programs in development contexts.

## 4.1. IMMEDIATE ACTIONS (LOW-HANGING FRUIT)

SCIENCE ASSESSMENT

1) *Perform a detailed verification analysis of forecasts at all timescales.*

Verification is the quantitative assessment of past performance of a prediction system, and is important because transparent information on past performance of a forecast system is an essential component of the credibility of the system. A primary function should be to inform the forecasters of any systematic errors in the forecasts so that adjustments can be made. At least some verification information should be made available to the forecast users, but the ultimate goal should be to make the verification information effectively redundant – information about forecast quality should be an inherent part of the forecast itself, being reflected in the forecast probabilities or in other formats representing the level of confidence that can be placed in the forecast, such as prediction intervals.

Since verification of officially released forecasts can be a sensitive issue, and since the value of such an analysis depends upon the availability of high quality observational data, it is imperative that the analysis be performed by DNM. To maximize benefit, a verification workshop held at DNM itself should be held. The primary objective of the workshop should be to identify any systematic errors in the forecasts issued operationally not only by DNM, but also by GTPA because, ultimately, it is the GTPA forecasts that are provided to the farmers. Assuming the availability of adequate observational data, it is suggested that a workshop of about one week would be required to verify the seasonal forecasts. The verification of the daily and weekly forecasts could similarly be conducted in a week, but may require advanced preparation because of the much larger data volumes involved compared to the seasonal timescale.

When verifying any forecasts, it is important to consider whether all available forecasts should be verified together or whether the analysis should look only at those forecasts that have been issued since the latest important change in the forecast system was implemented. The advantage of the latter option is that it provides an indication of the quality of the current forecast system, and thus is useful for interpreting current forecasts. However, the advantage of the former option is that a larger sample of forecasts is available, enabling a more thorough investigation of forecast quality. For seasonal forecasts, it is recommended that all available forecast be verified together since the sample size is so small, and, although there have been some developments in the predictors used, the procedure used to set the probabilities has remained substantially unaltered since operational forecasting was initiated in 1998. For the shorter-range forecasts it is viable to verify only the more recent forecasts, although having a history of how the forecast quality has evolved would be useful (see recommendation 2).

In addition to verifying past forecasts, it would be useful to have in place a process for verifying forecasts in an operational setting so that some kind of information is provided about the quality of a forecast almost immediately after the forecast period expires. This information will be useful for tracking changes in the quality of the forecasts.

2) *Review the analogue procedure for providing input to the agricultural decision-making process.*

Meteo Mali uses analogue years as part of its methodology in making seasonal forecasts. Analogue years that are defined as those that experienced a seasonal rainfall total closest to the amount predicted by a regression model can give an unreliable indication of the actual intra-seasonal characteristics. This method's limitation is that it is based on sampling events that have occurred in the past, which is a concern when it can be expected that the climate will change in ways that are unprecedented. Without explicitly understanding the differences between past climate regimes, whether persistently wet or dry periods, or the current variable period, analogues can lead to misleading interpretations of forecasts (Nicholls, 2001). In general the use of analogue years should probably be discouraged, especially if the number of years to be presented as analogues is small, but if their use is unavoidable, research should be conducted to identify means of selecting a more representative selection of years.

3) *Address the problem of declining numbers of stations.*

There are a reasonable number of stations over the southern half of Mali, though most of them may not be reporting on a real-time basis. However, the numbers of stations over the northern half of the country is limited, with no stations over many parts of the region. Combining data from available stations with satellite proxies could alleviate this problem. Satellite rainfall products go back to the early 1980s and have excellent spatial coverage. The accuracy of the satellite estimates itself could be improved significantly if calibrated with station observations. What matters is not simply setting up new instrumentation, but especially preserving to the extent possible the continuity in existing stations to preserve their time series data, since this is a region characterized by significant multi-decadal variations in climate.

4) *Implement a research program to investigate the predictability of the monsoon onset and cessation dates at one-week to one-month lead times, as well as the seasonal predictability of frequency of occurrence of dry spells or extreme precipitation events.*

In recent years promising advances have been made in case studies in neighboring Sahelian countries that demonstrate the potential predictability of quantities that describe the sub-seasonal character of precipitation, i.e., onset and cessation dates as well as frequency and intensity of precipitation, including duration of extreme dry spells. These should be researched in Mali. Seasonal forecasts of these quantities could be complemented with extended range weather forecasts. Given that the ECMWF forecasts are available to Mali via ACMAD, the skill of this model should be assessed, and onset and cessation date warnings should be designed in collaboration with representatives from the agricultural community bearing in mind the skill levels achievable.

5) *Review the procedures used to define forecast probabilities in seasonal forecasts.*

The procedure used to define the probabilities in DNM's seasonal forecasts is known to result in poor reliability despite its intuitive appeal. There is therefore scope to improve the way in which these forecast probabilities are calculated. Ideally this problem should be addressed at the regional scale, but previous attempts to do so have met with only short-lived success. Permanent change is likely to be achieved only if driven from the "bottom up" – i.e., by successful implementation at the national level in one or more countries, and then having these countries introduce the change(s) to regional practice.

6) *Promote the use of Global Producing Centre (GPC) model outputs in the production of seasonal climate forecasts.*

Developing the capacity of DNM to downscale GPC model outputs would be beneficial not only for potentially improving the skill of the seasonal forecasts, but also for building the capacity to implement forecasts at monthly, and possibly other, timescales since at least some of the procedures and tools involved will be common. The use of GPC products is being encouraged (primarily at the regional level) under the auspices of the so-called Second-Generation PRESAO (SG-PRESAO), and through associated training programs.

However, the uptake of GPC products at national level remains limited for a number of reasons. It is important to identify these reasons since additional efforts are otherwise likely to face similar constraints. One of the primary problems has been lack of easy access to the necessary GPC data in the correct format. It should be noted that these data access problems are multifold: both the hindcasts and operational updates need to be easily available; the data need to be in easily usable formats; the data volumes need to be manageable; the procedures for accessing all the required data need to be consistent from month to month.

While the IRI Data Library and CPT could be used to facilitate access to GPC data, simply using the Data Library with real-time forecasts available through the IRI is an inadequate solution because of the lack of IRI's status as a GPC, and because of the political importance of engaging other GPCs that are active in the region. At the minimum, Météo-France and the Met Office should be engaged in any attempt to promote use of GPC products. Both centers have indicated strong interest in having CPT used as a downscaling tool for their respective model outputs, and formal agreements should be sought between these centers, DNM, and ACMAD as a regional coordinating unit, to ensure that the relevant data are available operationally. The possibility of using the version of the Data Library installed ACMAD should be investigated, but further developments in the Data Library capabilities and or improvements in data selection capabilities within CPT should also be implemented to facilitate use of GCM in CPT since the current process is fairly complicated.

Apart from the difficulties with data access, there is also a problem of the GPC predictors being poorly understood, resulting in a perfectly reasonable reluctance to fully trust predictions derived from such sources. This problem could be addressed through adequate training but there is little point in holding a training workshop to promote the use of GPC data at DNM until a reliable system is in place for making the necessary GPC data easily available.

FIELD ASSESSMENT

7) *Investigate options for translating the probabilistic seasonal forecasts into language that communicates the uncertainty in the forecasts.*

It is often claimed that many target-users of seasonal forecasts do not understand the probabilistic nature of the forecasts. While this may be true, the blame is often placed on the probabilities, rather than on the fact that the probabilities are not communicating the uncertainty of understandable agricultural risks. Because the relevance of the rainfall terciles is not directly obvious the probabilities are difficult to interpret, and the probabilities per se may not actually be primary difficulty. Regardless, farmers do understand uncertainty, and will have their own ways of conceptualizing the problem of imperfect knowledge of the future, and of how to make decisions in that uncertainty. Ways of translating the probabilistic forecasts into such language should be explored.

8) *Initiate efforts to expand the advisories to better inform the use of scarce inputs and farm equipment, especially for poorer farmers with fewer assets.*

IER and other Malian partners are important knowledge resources with regard to farmer behavior, and should be engaged in an immediate effort to examine how the existing advisories might productively inform farmer decisions with regard to the use of inputs (how much and when) and equipment (improving the timing of equipment use to improve efficiency).

9) *Initiate efforts to expand the advisories to inform the likely availability of wild fodder, at least in the agroecological zones where livestock husbandry is a highly important, if not dominant, part of livelihoods.*

As currently designed, the advisories only speak to the likely conditions for growth of five crops. They do not inform our understanding of the growth of wild grasses and plants that are used for animal fodder. It is possible that farmers with livestock are able to interpret some advisories as proxies for fodder growth, but this was not examined in this assessment.

10) *Evaluate the availability of seed resources in Mali (or identify recent evaluations).*

There is circumstantial evidence to suggest that the impact of the advisories may be attenuated in clusters 1 and 3 by issues of seed availability. Where issues of availability are identified, we suggest that working with institutions such as IER to examine solutions to these challenges will be critical to the long-term success of the advisory program.

## 4.2. ISSUES AND CHALLENGES FOR RESOLUTION (MORE INFORMATION OR COORDINATION WITH OTHER ACTORS IS NEEDED)

SCIENCE ASSESSMENT

1) *Conduct research into identifying appropriate recommendations to make given the operational skill of the seasonal forecasts, and given realistically achievable skill levels.*

This activity requires the results from activities under recommendation 1 above. Procedures for translating seasonal forecasts into recommendations for farmers need to be researched. These recommendations could be informed by converting the seasonal climate forecasts into crop yield predictions, taking advantage of knowledge of observed rainfall to-date. There are numerous ways of making such predictions, and the most appropriate procedures given the skill levels of the climate forecasts and any operational resource and capacity constraints need to be identified.

2) *Support harmonization of regional seasonal forecasting.*

While it would be beneficial to update the climatological period used in producing the seasonal forecasts, the inconsistency with the regional forecasts is likely to prove problematic, and the availability of separate forecasts with different climatologies is likely to prove confusing. Instead a change in the climatological period should be encouraged at the regional level, perhaps working through individual national centres. It is probably inappropriate to do this in Mali alone, and it is likely best to work through WMO channels and regional institutes to achieve this goal.

FIELD ASSESSMENT

3) *Contextualize climate services in the context of rural livelihoods more broadly.*

This assessment covered clusters of villages (especially cluster 1) where livestock husbandry was a very important, if not dominant, part of local livelihoods. The demands of such husbandry, especially the need for fodder, appear to shape crop and variety selections to at least some extent. This effort should start with a research effort to better understand farmer crop and variety decisions as informed by both food and fodder needs.

Markets are also critical aspects of livelihoods decision-making, and can shape the ways in which advisories and other climate services are used (or not). Field research investigating the use of climate services in Senegal's Kaffrine Region found that some wealthier farmers were planting short-cycle peanut varieties without regard for seasonal forecasts or short-term forecasts because they were trying to time their harvest for hungry season, when prices are highest, and they have the resources to bounce back from a failed early planting. While farmers in Mali were not asked about this possibility in this assessment, certain patterns of variety selection (when GLAM farmers selected long-cycle millet and sorghum, but short-cycle peanuts) suggest that there are crops for which market forces and motivations will trump climate information. Similar field research should address the relative weight of markets in agricultural decision-making vis-à-vis weather and climate.

4) *Transform women's roles with reference to advisories.*

The transformation of the gendered patterns of use (and opportunities for use) of these advisories is a complex task. Because gender roles in livelihoods are often deeply rooted in community and household structure, we suggest that a detailed gender analysis of advisory use and livelihoods be undertaken, following the approach laid out by Carr and Thompson (2013), to identify appropriate opportunities to leverage such change. For example, such opportunities might include:

a) Identifying women's level of desire to cultivate GLAM crops, and facilitating that desire
b) Delivering new advisories that better speak to the crops most commonly grown by women

5) *Redesign community dissemination.*

The use of a rain gauge and farmer observer in each village to both localize advisories and serve as a means of disseminating agrometeorological information was an ingenious, low-cost solution to a complicated challenge. However, it is clear that this design requires rethinking to maximize the impact of the advisories. Selecting a single man as *the* farmer observer creates opportunities for gender bias in the dissemination of information, makes that observer vulnerable to the vagaries of probabilistic forecasts and the ire of the community, and places the local implementation of the program at risk should the farmer observer move or die, or the rain gauge be damaged. This model also does little to build broader weather- and climate-related capacity in the community. Community measurement and dissemination should be redesigned to address these challenges, ideally in coordination with the gender analysis efforts described under No. 4 above.

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# 6. APPENDIX I: FIELD DATA PRESENTATION AND ANALYSIS BY CLUSTER

*EDWARD R. CARR, UNIVERSITY OF SOUTH CAROLINA; KALIFA TRAORE, INSTITUT D'ECONOMIE RURAL; TSHIBANGU KALALA, UNIVERSITY OF SOUTH CAROLINA; LASSANA TOURE, INSTITUT D'ECONOMIE RURAL; CAROLYN WAGNER, STRATUS CONSULTING[4]; FIONA GAVIN, STRATUS CONSULTING; ANTHONY BERENGUEL, STRATUS CONSULTING; PIERRE C. SIBIRY TRAORE, INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS; NATHAN BRAUN, STRATUS CONSULTING; MICHAEL DUCKWORTH, STRATUS CONSULTING; THOMAS HODGSON, STRATUS CONSULTING; JOEL SMITH, STRATUS CONSULTING; JUSTIN STEIN, STRATUS CONSULTING*

## 6.1. INTRODUCTION: FIELD ASSESSMENT DATA

This appendix presents the data on livelihoods and program use for each cluster. Each discussion follows the same general structure, beginning with a general discussion of the vulnerability context. While all four clusters have broadly similar vulnerability contexts, there are differences between clusters that shape livelihoods decisions, especially agricultural decisions. This discussion includes a review of the broad livelihoods challenges identified in the literature and by residents in focus groups.

From the vulnerability context, discussion turns to an overview of livelihoods activities in the cluster. This discussion allows for a preliminary assessment of the fit between livelihoods activities and the challenges presented by the vulnerability context, and provides an entry point to understanding the livelihoods roles played by different members of each community. Further, an overview of livelihoods contextualizes agriculture (the activity targeted by the agrometeorological advisory program) in the broad suite of activities undertaken by the residents.

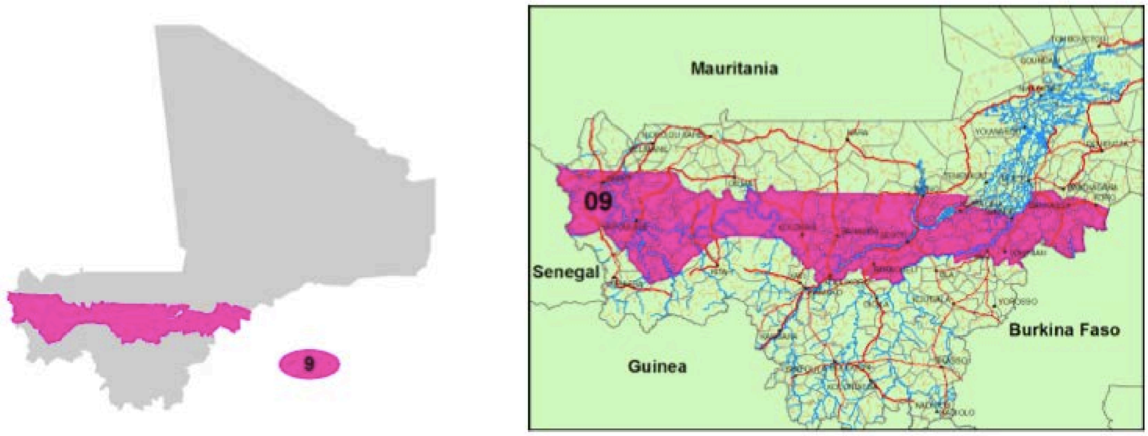
The third part of each cluster discussion focuses on agricultural practice and decision-making. This section of the discussion is an overview of the different crops and varieties raised in each cluster, who raises those crops/varieties, and the uses that these different farmers intend for their crops. This discussion highlights the different agricultural vulnerabilities experienced by different members of these communities, the different potential values the agrometeorological advisories have for community members, and any evidence for the impact of the advisories on decision-making as manifest in crop and variety selection.

[4] Stratus Consulting authors all based in Boulder, CO, USA.

Finally, each cluster discussion closes with a summary discussion of possible program impacts within the cluster. This discussion includes a *preliminary* behavioral model that discusses the likely motivations for existing livelihoods and agricultural decisions by the different cohorts in each cluster – that is, the model seeks to explain why the members of each cohort conduct the activities they do, instead of other activities. This model is *provisional*, as in each cluster it is largely based on circumstantial evidence that should be interrogated with ethnographic investigation to validate this model.[5] While provisional and preliminary, the models presented here that can inform the design of program modifications, including new services and delivery methods. Further, these models should inform future ethnographic investigations which can validate or otherwise refine these models.

[5] Following Carr (2013), the establishment of such a behavioral model requires understanding the discourses of livelihoods, tools of coercion, and mobilization of identity behind livelihoods decisions. The existing data presents some evidence in each of these arenas, though the depth of this information varies. Further, to really piece together a behavioral model, the intersection of these three arenas has to be interrogated explicitly. This activity was outside the scope of this initial assessment.

## 6.2. CLUSTER 1 - ML09 "WEST AND CENTRAL RAINFED MILLET/SORGHUM"




**Location of the livelihoods zone to which Cluster 1 villages belong. Source: Dixon and Holt, 2010, p.86.**

### 6.2.1. VULNERABILITY CONTEXT

The villages of Cluster 1 are located at the edge of the Sudanian zone, bordering on the Sahel. Annual precipitation ranges between 600 and 800mm per year (Dixon & Holt, 2010, p.86). Rainfall is highly seasonal, with nearly all coming between late May and early October. Most falls from late June through August. From June to September, households experience a hungry season as annual stocks of food run out before the new harvest is ready. This is a long hungry season relative to other clusters in this study, though the length and depth of the season varies depending on the quality of the previous years' harvest and the wealth and assets of individuals and households. The mismatch between household assets and the timing of the harvest often requires poorer households to take out loans for agricultural materials or food during this season. These loans are then repaid with the returns from the harvest (Dixon & Holt, 2010, p.88).

Farmers in this cluster sell at least some of their crops at market, but this is not a heavy focus in their livelihoods. Sesame and cotton are the most common cash crops, but both occur infrequently on the farms of this sample. Sesame is commonly sold as a cash crop, which Dixon and Holt (2010, p. 87) trace through markets in Bamako to markets in the Middle East. Cotton sales are controlled by the Compagnie Malienne du Développement des Textiles (CMDT) (Dixon & Holt, 2010, p.86). Farmers growing these crops are therefore exposed to instability in national markets, especially political instability that might compromise either parastatals or the continuing function of export markets for their crops. All other crops are staples generally sold on local markets for Malian consumption, and therefore more directly impacted by market fluctuations or harvest outcomes that impact local (Malian) purchasing power. The sale of these crops is predicated a surplus harvest and, since they can be locally consumed or sold, cultivation of these crops can serve as a household hedge against either market instability or farm-level factors like precipitation and pests that might impact production.

The Livelihood Profiling and Zoning Report commissioned by the Famine Early Warning System Network (Dixon & Holt, 2010, pp.91-92) discusses a range of livelihoods challenges that emerge in this zone. These include chronic challenges such as livestock theft, malaria, and a lack of adequate pastureland for livestock, and periodic challenges including insufficient rainfall, crop-damaging pests, livestock diseases, flooding, and bushfires.

| Senior Men | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Low access to land | 1.0 | 4.0 | 3.5 |
| Lack of inputs | | 1.0 | 1.5 |
| Irregular/inadequate rainfall | | 2.0 | 1.0 |
| Lack of farming equipment | | 2.0 | 2.0 |
| Land cover and soil degradation | | 2.0 | 2.0 |
| Water availability | | 4.0 | 6.0 |
| Lack of good seeds | | | 3.0 |
| Lack of animal fodder | | | 5.0 |
| Animal health/vets | | | |
| Food Shortage | | | 3.5 |
| Livestock management | | | 3.7 |
| Pests | | | 3.0 |
| Cattle Stealing | | | 5.0 |

| Junior Men | GLAM average | Former GLAM average | Control Average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1.0 | 2.0 | 1.5 |
| Lack of farming equipment | 2.0 | 1.0 | 1.5 |
| Lack of inputs | 3.0 | 2.0 | 3.8 |
| Low access to land | 4.0 | 3.7 | 2.5 |
| Animal health/vets | 5.0 | | |
| Water availability | | 2.0 | 5.0 |
| Lack of good seeds | | 3.0 | |
| Lack of animal fodder | | 3.0 | |
| Land cover and soil degradation | | 5.0 | 5.0 |
| Market problems | | | 3.0 |
| Food Shortage | | | 6.0 |
| Pests | | | 4.0 |
| Cattle Stealing | | | 4.0 |

| Senior Women | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Water availability | | 1.0 | 1.0 |
| Irregular/inadequate rainfall | 1.0 | | 1.0 |
| Lack of farming equipment | | 2.7 | 2.0 |
| Lack of inputs | 4.0 | 2.7 | 2.8 |
| Lack of good seeds | | 3.0 | 4.0 |
| Lack of animal fodder | 5.0 | 4.0 | 3.0 |
| Animal health/vets | 3.0 | | 6.0 |
| Low access to land | | | 4.0 |
| Food Shortage | | | 5.0 |
| Pests | 2.0 | | 5.0 |

| Junior Women | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1.0 | 1.0 | 3.5 |
| Lack of inputs | 2.0 | 1.5 | 3.5 |
| Lack of good seeds | 2.0 | | 3.5 |
| Land cover and soil degradation | 3.0 | | 3.7 |
| Pests | 4.0 | 3.0 | 6.0 |
| Animal health/vets | | 2.0 | 1.0 |
| Water availability | | 3.0 | 1.5 |
| Lack of farming equipment | | 3.0 | 1.5 |
| Low access to land | | 3.0 | 2.0 |
| Lack of animal fodder | | | 2.0 |
| Illness | | | 1.0 |

**Figure A1: Principal livelihoods challenges, as reported by focus groups in cluster 1. Numbers in each table represent the average ranking of each challenge by focus groups of individuals from that cohort, with 1 being the most important challenge. They are sorted here by the most to least important challenge, first in GLAM villages, then former GLAM, then Control. Blank cells indicate that nobody in that focus group identified the issue as a challenge.**

The field assessment of Cluster 1 uncovered several hazards and stresses not mentioned in the FEWS-NET report, including inadequate water availability, lack of access to adequate farming equipment and inputs, and soil degradation (Figure A1). The concerns for access to farming equipment and inputs, and soil degradation were more important for men than women. Water availability was a relatively minor concern for all groups in this cluster except senior women. As much of their gardening is hand irrigated, these women were the group most sensitive to changing or inadequate access to groundwater throughout the year. Food shortage was generally listed as a minor problem, likely because it is chronic due to the annual recurrence of a hungry season. However, it is worth noting that only those living in control villages listed food shortage as a problem. It never arose in focus group discussions in GLAM villages or former GLAM villages. The source of this variable perception is unclear. It could have been an outcome of program participation, but equally could reflect qualities of farmers in these villages that led to their selection for participation in the program in the first place. Market problems, including delayed payments from CMDT, never arose in focus groups as a particular stress or challenge. This is likely a product of two factors: the broad production strategy in this cluster, shared across all cohorts, where the bulk of agricultural production can be consumed directly by members of the household, with any surplus for sale, and the fact that CMDT appears to be chronically late in payment, making this more a constant than a unique stressor. This strategy was shared across gender and seniority lines, suggesting a similar level of exposure to market instability across all residents of this cluster. However, the absence of market instability in discussions with the different cohorts suggests that such instability is at worst chronic, and considered manageable by the farmers under their existing livelihoods strategies.

### 6.2.2. LIVELIHOODS IN CLUSTER 1

Livelihoods in the nine villages of cluster 1 were dominated by agricultural activities and livestock husbandry, with business/trading activities rounding out the most common sources of income in these communities (Figure A2).

| | GLAM senior man (N=5) | Former GLAM senior man (N=15) | Control Senior Man (N=25) | GLAM Senior Woman (N=6) | Former GLAM senior Woman (N=15) | Control Senior Woman (N=24) | GLAM Junior Man (N=5) | Former GLAM Junior Man (N=16) | Control Junior Man (N=24) | GLAM Junior Woman (N=5) | Former GLAM Junior Woman (N=15) | Control Junior Woman (N=25) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 91.67% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 96.00% |
| Livestock | 100.00% | 86.67% | 68.00% | 83.33% | 46.67% | 41.67% | 80.00% | 68.75% | 83.33% | 100.00% | 40.00% | 60.00% |
| Business | 0.00% | 13.33% | 24.00% | 83.33% | 80.00% | 50.00% | 0.00% | 12.50% | 16.67% | 80.00% | 93.33% | 48.00% |
| Picking/gathering | 0.00% | 0.00% | 0.00% | 83.33% | 46.67% | 25.00% | 0.00% | 0.00% | 0.00% | 80.00% | 0.00% | 0.00% |
| Gardening | 0.00% | 0.00% | 0.00% | 83.33% | 26.67% | 25.00% | 0.00% | 0.00% | 0.00% | 80.00% | 0.00% | 8.00% |
| Other | 0.00% | 6.67% | 4.00% | 0.00% | 13.33% | 12.50% | 40.00% | 31.25% | 12.50% | 0.00% | 0.00% | 4.00% |
| Handicrafts | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.00% | 18.75% | 4.17% | 40.00% | 0.00% | 8.00% |
| Logging | 0.00% | 0.00% | 0.00% | 83.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Agroforestry | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 4.17% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Figure A2: Livelihoods activities in cluster 1.**

Overall, livelihoods in both GLAM, former GLAM, and control villages emphasized agriculture, regardless of gender or seniority. However, under this broad livelihoods characterization there were complex differentiations. For both junior and senior men in all villages, livestock husbandry was the second most common livelihoods activity. Rates of participation were highest for senior men in GLAM villages, though at least 69% men in each cohort, whether in GLAM, former GLAM, or control villages, raised livestock. Fewer women than men raised livestock in all cohorts and village types except junior women in GLAM villages. This apparent gendering of livestock husbandry is also manifest in the types of animals owned by men and women. Men generally owned cows and donkeys, with other animals mixed in. Women tended to focus on goats and poultry. This division was consistent across all cohorts and village types. For women, trading was the second most common livelihoods activity. Their participation ranged from two to five times the rate of men in the same cohort. While junior and senior women participated in this activity at roughly the same rate, those living in GLAM villages and former GLAM villages had very similar rates of participation (≈80% to 90%), while those in control villages had lower rates of participation (≈50%). Women in different villages had different engagements with three female-dominated activities: picking/gathering, gardening, and wood-cutting (for firewood or charcoal). These activities were most commonly seen among senior women in GLAM villages (≈80% participation for all three). Senior women in former GLAM villages participated in gathering/picking and gardening, albeit at lower rates (47% and 27%, respectively), but did not cut wood. Senior women in control villages had the lowest rates of participation in gathering/picking and gardening (25% for both), and also did not participate in wood-cutting. Note that junior women in both former GLAM and control villages either participated at very low rates (8% of junior women in control village garden) or did not participate in these activities at all, suggesting a gender/seniority framing of identity and livelihoods roles associated with these activities.

The overall livelihoods structure in cluster 1 demonstrates different exposures to potential shocks and pressures shaped by the roles and responsibilities assigned to particular intersections of gender and seniority, and thus the complexity of the vulnerability context(s) their livelihoods address. Men in general were the most vulnerable to climate variability and environmental degradation, as they depended on rain-fed agriculture and cattle, donkey, goat, and sheep husbandry (which required rangeland and fodder) for the bulk of their income. Junior men appeared to mitigate some of the vulnerability of their livelihoods to climate variability and economic uncertainty through livelihoods diversification into handicrafts work and miscellaneous labor opportunities. Women appeared more resilient in the face of climate variability because a significant fraction of their activities include irrigated gardening, and their livestock husbandry was focused on smaller, less fodder-intensive animals. That said, it is worth noting that the women most engaged in livestock husbandry (those in GLAM villages) tended to rank variable precipitation as a larger concern than did their counterparts in other villages. Women's high levels of engagement with trading and business were likely closely tied to the sale of any agricultural surpluses from their farms and perhaps the farms of their households, and in the case of senior women, the wild foods they gathered (junior women were not engaged in gathering, though the reason for this is not explained by the data). This suggests that engagement in business and trade in these villages is not a significant diversification away from agricultural livelihoods activities. While these activities exposed them directly to swings in local and national markets, that exposure was mitigated by the nature of the commodities, which could be eaten or sold at market, depending on market conditions. Given women's heavy participation in gardening, it is surprising that their principal concerns so often came to rest on rainfall variability. Those women most engaged in gardening and livestock husbandry, junior and senior women living in GLAM villages, did not mention water availability as an issue at all despite their reliance on hand irrigation for their gardens and the need to water their animals.

### 6.2.3. AGRICULTURE IN CLUSTER 1

While those living in the villages of cluster 1 manage their vulnerability context through a suite of livelihoods activities, agriculture remained the dominant activity in this cluster. As with livelihoods, agricultural practice was differentiated by seniority and gender in this cluster. The choices individuals made with regard to crop selection, crop use, and variety selection all provided further information not only about how different people in this cluster address the vulnerability context, but also to what they were most exposed. By comparing those with access to agrometeorological advisories to others in the cluster, we can identify the potential impacts of the agrometeorological program on agricultural decisions.

In this cluster, farmers raised 23 crops, including all five GLAM crops (Table A1). Women dominated the cultivation of ten of these crops[6], but none of these "women's crops" was a GLAM crop. Instead, all were associated with gardening, which is often hand-irrigated. In this cluster only one crop, cotton, might have been classified as a men's crop, and it is a crop targeted by the agrometeorological program. Men in all three village types raised millet much more frequently than women. This suggests that men were somewhat more likely to benefit from the program than women, as men exclusively planted one of the five crops for which advisories were provided, and dominated the planting of another. Women's domination of gardened crops suggests resilience in the face of variable precipitation, for, while they cultivate several rain-fed crops, much of their agricultural production was not reliant on precipitation, but instead on adequate sources of groundwater to facilitate irrigation.

[6] For the purposes of this assessment, the question of a crop's "gender" is one of emphasis. We consider the production of a crop to be "gendered" when its cultivation is clearly dominated by one gender, including instances where one or two members of the opposite gender are growing that crop.

| | GLAM senior man | Former GLAM senior man | Control Senior Man | GLAM Senior Woman | Former GLAM Senior Woman | Control Senior Woman | GLAM Junior Man | Former GLAM Junior Man | Control Junior Man | GLAM Junior Woman | Former GLAM Junior Woman | Control Junior Woman |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg # Crops | 5.4 | 4.266667 | 3.6 | 6.833333 | 4.066667 | 3.875 | 4.4 | 4.1875 | 4.583333 | 5.2 | 2.6 | 2.08 |
| Peanuts | 100.00% | 73.33% | 48.00% | 100.00% | 80.00% | 58.33% | 80.00% | 75.00% | 87.50% | 100.00% | 66.67% | 48.00% |
| Eggplant | 0.00% | 0.00% | 0.00% | 16.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% | 0.00% |
| Other | 100.00% | 0.00% | 32.00% | 33.33% | 6.67% | 25.00% | 100.00% | 6.25% | 37.50% | 0.00% | 0.00% | 12.00% |
| Cabbage | 0.00% | 0.00% | 0.00% | 16.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Cotton | 0.00% | 0.00% | 4.00% | 0.00% | 0.00% | 0.00% | 0.00% | 6.25% | 12.50% | 0.00% | 0.00% | 0.00% |
| Fonio | 60.00% | 33.33% | 24.00% | 0.00% | 6.67% | 20.83% | 40.00% | 31.25% | 50.00% | 0.00% | 0.00% | 0.00% |
| Okra | 0.00% | 0.00% | 0.00% | 83.33% | 86.67% | 41.67% | 0.00% | 0.00% | 0.00% | 100.00% | 53.33% | 32.00% |
| Lettuce | 0.00% | 0.00% | 0.00% | 16.67% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% | 0.00% |
| Maize | 20.00% | 33.33% | 16.00% | 16.67% | 0.00% | 8.33% | 0.00% | 18.75% | 45.83% | 0.00% | 0.00% | 4.00% |
| Melon | 0.00% | 0.00% | 0.00% | 33.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Millet | 60.00% | 93.33% | 100.00% | 0.00% | 33.33% | 50.00% | 40.00% | 93.75% | 91.67% | 0.00% | 26.67% | 32.00% |
| Cowpea | 60.00% | 40.00% | 48.00% | 66.67% | 60.00% | 54.17% | 0.00% | 56.25% | 20.83% | 40.00% | 33.33% | 24.00% |
| Onion | 0.00% | 0.00% | 0.00% | 0.00% | 13.33% | 4.17% | 0.00% | 0.00% | 0.00% | 0.00% | 13.33% | 20.00% |
| Roselle | 0.00% | 0.00% | 0.00% | 33.33% | 6.67% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Papaya | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 12.50% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Watermelon | 0.00% | 0.00% | 4.00% | 16.67% | 0.00% | 0.00% | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% |
| Chili pepper | 0.00% | 0.00% | 0.00% | 16.67% | 6.67% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 8.00% |
| Potato | 0.00% | 0.00% | 0.00% | 16.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Rice | 0.00% | 26.67% | 0.00% | 0.00% | 0.00% | 4.17% | 0.00% | 31.25% | 8.33% | 0.00% | 0.00% | 0.00% |
| Sesame | 40.00% | 13.33% | 24.00% | 66.67% | 26.67% | 12.50% | 80.00% | 6.25% | 33.33% | 100.00% | 13.33% | 16.00% |
| Sorghum | 100.00% | 86.67% | 56.00% | 66.67% | 40.00% | 29.17% | 100.00% | 93.75% | 54.17% | 60.00% | 26.67% | 0.00% |
| Tomato | 0.00% | 0.00% | 0.00% | 83.33% | 26.67% | 20.83% | 0.00% | 0.00% | 0.00% | 80.00% | 26.67% | 12.00% |
| Bambara nut | 0.00% | 26.67% | 4.00% | 0.00% | 13.33% | 16.67% | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% |

| | |
|---|---|
| Onion | Women's crop |
| Rice | Men's crop |
| Sorghum | Crop targeted by the agromet program |

**Table A1: All crops grown in cluster 1, by subgroup and GLAM/Former GLAM/control village.**

Senior Men

This cluster only contained a single GLAM village, and therefore only five senior men who might have been receiving the advisories in the manner intended by the program. Eighty percent (n=4) of these men claimed to be using the advisories. All men claiming to use the advisories had a good understanding of how the program worked. Thus, there is little concern in this small sample for the "noise" of non-participants or uninformed farmers in GLAM villages altering the overall picture of crop or variety selection such that we cannot detect patterns of possible influence and impact on agricultural decisions and behavior.

Figure A3 compares the crop selection preferences of senior men across GLAM, former GLAM, and control villages. Senior men in GLAM villages planted an average of 5.0 crops on their farms, a larger amount than in former GLAM or control villages. A larger percentage of senior men in GLAM villages grew peanuts and sorghum than those in former GLAM or control villages. A smaller percentage of senior men in GLAM villages grew millet than in either former GLAM or control villages. These differences are hard to interpret, as the number of GLAM respondents is very low, and differences in response associated with a single farmer can introduce apparently large swings in patterns of crop selection. Therefore, it is difficult to attribute these differences to the use of agrometeorological advisories.

**GLAM senior man**

| | |
|---|---|
| Avg # crops | 5.0 |
| Peanut | 100.00% |
| Sorghum | 100.00% |
| Millet | 80.00% |
| Fonio | 60.00% |
| Cowpeas | 60.00% |
| Henna | 40.00% |
| Sesame | 40.00% |
| Maize | 20.00% |

**Former GLAM senior man**

| | |
|---|---|
| Avg # crops | 4.3 |
| Millet | 93.33% |
| Sorghum | 86.67% |
| Peanut | 73.33% |
| Cowpeas | 40.00% |
| Fonio | 33.33% |
| Maize | 33.33% |
| Rice | 26.67% |
| Bambara nuts | 26.67% |
| Sesame | 13.33% |

**Control Senior Man**

| | |
|---|---|
| Avg # crops | 3.4 |
| Millet | 100.00% |
| Sorghum | 56.00% |
| Peanut | 48.00% |
| Cowpeas | 48.00% |
| Fonio | 24.00% |
| Sesame | 24.00% |
| Maize | 16.00% |
| Henna | 12.00% |
| Cotton | 4.00% |
| Watermelon | 4.00% |
| Bambara nuts | 4.00% |

**Figure A3: The crop selection preferences of senior men in cluster 1. GLAM crops are highlighted in black.**

Figure A4 shows the pattern of crop selection among senior men in the GLAM village. Unsurprisingly, there is no real difference in pattern of selection, as 80% of these men claimed to be using the information.

**GLAM Senior Man: All**

| | |
|---|---|
| Avg # crops | 5.0 |
| Peanut | 100.00% |
| Sorghum | 100.00% |
| Millet | 80.00% |
| Fonio | 60.00% |
| Cowpeas | 60.00% |
| Henna | 40.00% |
| Sesame | 40.00% |
| Maize | 20.00% |

**GLAM Senior Man: Definite**

| | |
|---|---|
| Avg # crops | 4.75 |
| Peanut | 100.00% |
| Sorghum | 100.00% |
| Millet | 75.00% |
| Cowpeas | 75.00% |
| Fonio | 50.00% |
| Henna | 50.00% |
| Sesame | 25.00% |

**Figure A4: The crop selections of senior men in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

Figure A5 represents the patterns of variety selection among the crops for which there is an agrometeorological advisory each year. At the level of village type, there was very little difference in the patterns of millet and sorghum variety selection. For peanuts, senior men in GLAM villages concentrated exclusively on short cycle varieties, while those in control and former GLAM villages seemed to be hedging a general emphasis on short-cycle varieties with some emphasis on long-cycle varieties. There were also clear differences in maize variety selection. The senior men in GLAM villages were all growing a middle-duration variety. Those in former GLAM villages were growing short cycle varieties. In control villages, senior men spread their variety selection across all three cycles. In the case of maize, this suggests that senior men in GLAM villages are making this selection with different information than those in the other two village types.

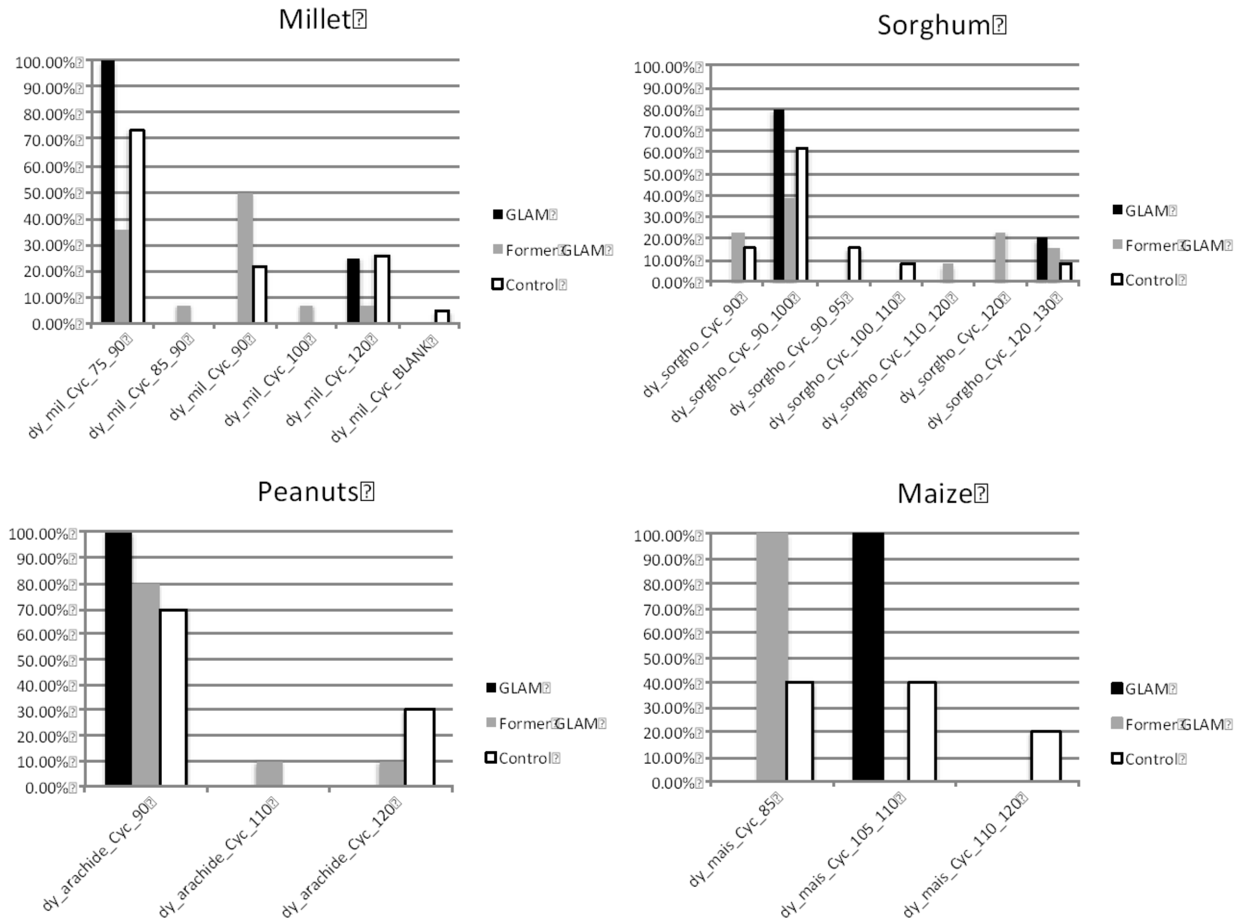



**Figure A5: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types. The shortest-cycle varieties are on the left of each x-axis, and the longest-cycle varieties to the right.**

The single advisory for which we have evidence comes from the 3rd dekad of May 2011. In that advisory, farmers in this cluster (at least those around Segou) were told they could plant four month (120-day) cycles of sorghum, millet, maize, and peanuts once local rainfall exceed 20mm in a single 10-day stretch. The May advisories paint a picture of below-normal rainfall for this cluster, suggesting that the farmers using these advisories did not see this amount of rainfall at least until some time in June, as by the start of July precipitation totals had returned to normal. What seems most likely from the evidence at hand is that the GLAM farmers in this cohort planted much shorter cycles of peanuts, sorghum, and millet than initially advised (though their maize variety selection is consistent with the advisory) because they did not see enough local rainfall to act on the initial advisories, and only planted later when much shorter-cycle varieties were all that were viable. It is important to note, however, that this explanation is provisional, as these decisions also could have been shaped by other needs, including a desire to harvest and sell crops at the end of the hungry season, when prices are highest, or the need to provide fodder for animals (via sorghum and post-harvest peanut plants) during the hungry season. Deeper investigation of these decisions is required before any concrete statements about advisory efficacy can be made.

The variety selection data associated with senior men in this cluster tells a worrying story. While for some crops they plant varieties with a range of cycles, at an individual level farmers of all village types are focused on planting a single variety of each GLAM crop on their farms. This is a general trend across all villages, regardless of access to advisories. The presence of this pattern in GLAM villages suggests that these farmers are heavily influenced by the advisories' current focus on a single cycle length (instead of a recommended distribution of cycle lengths) potentially increasing their risk of major losses should the season run contrary to the forecast. Unless there is a community-level means of redistributing farm production, the "diversity" of cycles seen on these farms is really an aggregation of many individual, risky selections. This issue will have to be explored carefully in future research.

As seen in Figure A6, there were no significant differences in variety selection among all senior men in GLAM villages, and those claiming to use advisories, and those able to describe the workings of the program. This is again likely because 80% of all senior men claimed to use the advisories.

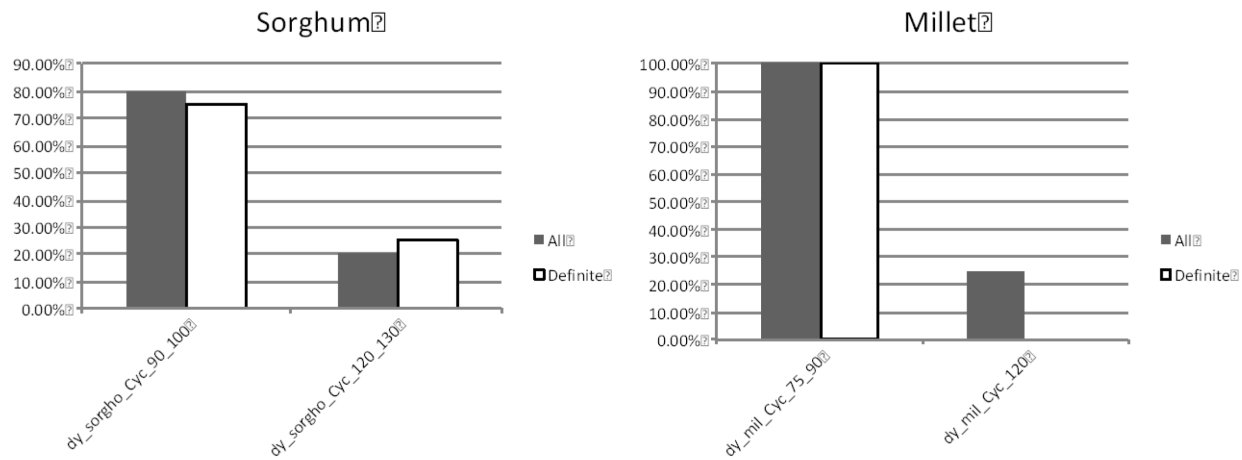



**Figure A6: Comparisons of variety selection among senior men in GLAM villages, comparing all such men and those that used the advisories and accurately reported the workings of the program.**

Figure A7 displays the intended uses of each of the crops grown by two or more senior men in GLAM, former GLAM, and control villages.[7] While the overall agricultural strategies revealed by this information are broadly similar, this table does suggest a small difference in agricultural outcomes between those with the advisories and those operating without them. Senior men in GLAM villages were more market oriented with their production than their counterparts in former GLAM or control villages, growing at least three or four crops that they intended for consumption and sale. In former GLAM and control villages, these men were growing between one and two such crops. As crop selection is quite similar across village types and access to advisories, it appears that those in GLAM villages had greater

[7] Only using crops raised by two or more farmers is a small check against individual, idiosyncratic valuations of particular crops.

confidence in generating yields that would meet the subsistence needs of their households and produce a marketable surplus than those in other villages. Senior men in former GLAM and control villages exhibited a more defensive agricultural strategy, focusing on subsistence ahead of any expectation of market engagement.

**GLAM senior man**

| | |
|---|---|
| Peanut | Eat more than sell |
| Sorghum | Eat all |
| Millet | Eat all |
| Fonio | Eat more than sell |
| Cowpeas | Eat more than sell |
| Henna | Sell all |
| Sesame | Sell all |
| Maize | Eat all |

**Former GLAM senior man**

| | |
|---|---|
| Millet | Eat all |
| Sorghum | Eat all |
| Peanut | Eat and sell equally |
| Cowpeas | Eat more than sell |
| Fonio | Eat all |
| Maize | Eat all |
| Rice | Eat all |
| Bambara nuts | Eat all |
| Sesame | Sell all |

**Control Senior Man**

| | |
|---|---|
| Millet | Eat all |
| Sorghum | Eat all |
| Peanut | Eat more than sell |
| Cowpeas | Eat all |
| Fonio | Eat all |
| Sesame | Sell all |
| Maize | Eat all |
| Henna | Sell all |
| Cotton | Sell all |
| Watermelon | Sell all |
| Bambara nuts | Eat all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A7: Intended uses of all crops on two or more senior men's farms for cluster 1.**

There was little to separate the agricultural production strategies of senior men living in the different villages of this cluster. Their strategies were very conservative, hedged against both climate variability and market instability. Cash crops like sesame were rare on these farms, and highly-marketable peanuts were used for subsistence first before being sold. However, there were differences in the degree to which these strategies are marked by conservatism across the three village types. Senior men in GLAM villages appear to have had higher expectations of meeting both subsistence and market sale goals from their agricultural production than those in both former GLAM and control villages. When considering agricultural strategies, it is also important to note that a significantly larger number of these men in both GLAM and former GLAM villages participated in animal husbandry than did their control counterparts. Both sorghum and peanut (the leftover plants after harvest) were sources of fodder, and given that men in both GLAM and former GLAM villages did not list fodder as a concern (as compared to their control counterparts, who did), it is likely that the need to support their animals contributed to their crop selections. This interpretation has to be investigated carefully. The desire to profit from high market prices during the hungry season might drive the selection of short-cycle varieties by senior men in GLAM villages, trumping the information provided by the advisories. However, harvesting early usually means that the peanut plant cannot be adequately dried and used for fodder, a critical tradeoff that could explain the higher rates of sorghum cultivation in GLAM and former GLAM villages. Thus, it is possible that solid advisories might actually reduce available fodder in a given year. We cannot determine which of these possible connections, if either, is at work in this cluster with the data at hand.

Junior Men

Among junior men, 80% of the respondents (n=4, from a single village) reported using the advisories to inform their agricultural practice. Of these, 75% (n=3) demonstrated an understanding of how the agrometeorological program worked. This presents the possibility that the non-participating or misinformed junior men in the GLAM village might distort the patterns of crop and variety selection, obscuring patterns of influence from the advisories. An analysis of these patterns that separates those clearly using the advisories from other farmers, however, demonstrates that there is little difference between those who clearly use the advisories and those that do not (see figures A9 and A12, and related discussion). This might suggest that the advisories have little practical value-add in informing agricultural practice in this GLAM village, or that farmers who do not fully understand the program may either follow the lead of those who do use the advisories. We cannot parse this possibility with the data at hand.

Junior men grew roughly the same number of crops whether in GLAM, former GLAM, or control villages (Figure A8). Fewer junior men grew millet in GLAM villages than former GLAM or control villages, but because of the very small sample size of junior men in GLAM villages it is difficult to interpret the significance of these differences. Those in GLAM and former GLAM villages grew sorghum almost twice as frequently as junior men in control villages, which is a clearer difference in selection.

**GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 4.6 |
| Sorghum | 100.00% |
| Peanut | 80.00% |
| Henna | 80.00% |
| Millet | 80.00% |
| Sesame | 80.00% |
| Fonio | 40.00% |

**Former GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 4.2 |
| Sorghum | 93.75% |
| Millet | 93.75% |
| Peanut | 75.00% |
| Cowpeas | 56.25% |
| Fonio | 31.25% |
| Rice | 31.25% |
| Maize | 18.75% |
| Sesame | 6.25% |
| Cotton | 6.25% |
| Roselle | 6.25% |

**Control Junior Man**

| | |
|---|---|
| Avg # crops | 4.5 |
| Millet | 100.00% |
| Peanut | 87.50% |
| Sorghum | 54.17% |
| Fonio | 50.00% |
| Maize | 45.83% |
| Sesame | 37.50% |
| Cowpeas | 20.83% |
| Henna | 16.67% |
| Cotton | 12.50% |
| Watermelon | 8.33% |
| Rice | 8.33% |
| Bambara nuts | 8.33% |
| Roselle | 4.17% |

**Figure A8: The crop selection preferences of junior men in cluster 1.**

Crop selections within the GLAM villages displayed little difference between those who clearly did not use the advisories, those that might have used the advisories (as self-reported), and those that clearly were using the advisories (reported using them, and demonstrated an understanding of how the program works) (Figure A9).

**GLAM Junior Man: All**

| | |
|---|---|
| Avg # crops | 4.6 |
| Sorghum | 100.00% |
| Peanut | 80.00% |
| Henna | 80.00% |
| Millet | 80.00% |
| Sesame | 80.00% |
| Fonio | 40.00% |

**GLAM Junior Man: Probable**

| | |
|---|---|
| Avg # crops | 4.5 |
| Peanut | 100.00% |
| Sorghum | 100.00% |
| Henna | 75.00% |
| Millet | 75.00% |
| Sesame | 75.00% |
| Fonio | 25.00% |

**GLAM Junior Man: Definite**

| | |
|---|---|
| Avg # crops | 4.333333 |
| Peanut | 100.00% |
| Sorghum | 100.00% |
| Henna | 66.67% |
| Millet | 66.67% |
| Sesame | 66.67% |
| Fonio | 33.33% |

**Figure A9: The crop selections of junior men in GLAM villages, by all, those who claim to use advisories, and those that claim to use advisories and understand how the program works.**

Considered in light of the single cluster-specific advisory for which there is evidence, the variety selections of junior men in GLAM villages appear to apply the agrometeorological advisories to their crops. Their sorghum selections ran toward the four-month (120-day) cycles recommended in the advisory, which makes sense as it is an early-planting crop. Their peanut and millet selections, however, were much, much shorter than initially advised. At the community level, junior men in GLAM villages were completely focused on short-cycle millet, while those in the other villages distributed their selections across a range of varieties (Figure A10). It appears that this pattern might be related to the lower-than-normal levels of rainfall across this cluster through May, where these men were forced to delay planting until they were forced into short-cycle varieties. It is not clear if this pattern can be solely attributed to the advisories, as other factors that influence crop selections. For example, the choice of short cycle peanuts might reflect fodder needs during the hungry season that cannot be put off for longer-cycle peanuts, or a desire to ensure that the crop is harvested during the hungry season when prices are highest. Further, the choice of long-cycle sorghum may be related to fodder needs in the household for which a later harvest is most useful. In all other cases, the variety selections of those in GLAM villages did not differ greatly from those in the other villages.

At an individual (as opposed to community) level, most junior men, regardless of access to advisories, focused on planting a single cycle of each GLAM crop they raised, exposing individual farmers and their households to heightened risk from climate variability that might lengthen or shorten the season. As junior men did not list seed availability as a problem they had to address, it appears that this strategy is voluntary. While problematic in all villages, the presence of this selection strategy in the GLAM village suggests that the farmers are using the advisories as a means of selecting *the* correct variety (reflecting the tone of the advisories themselves) to properly distribute their production across varieties to manage risk.

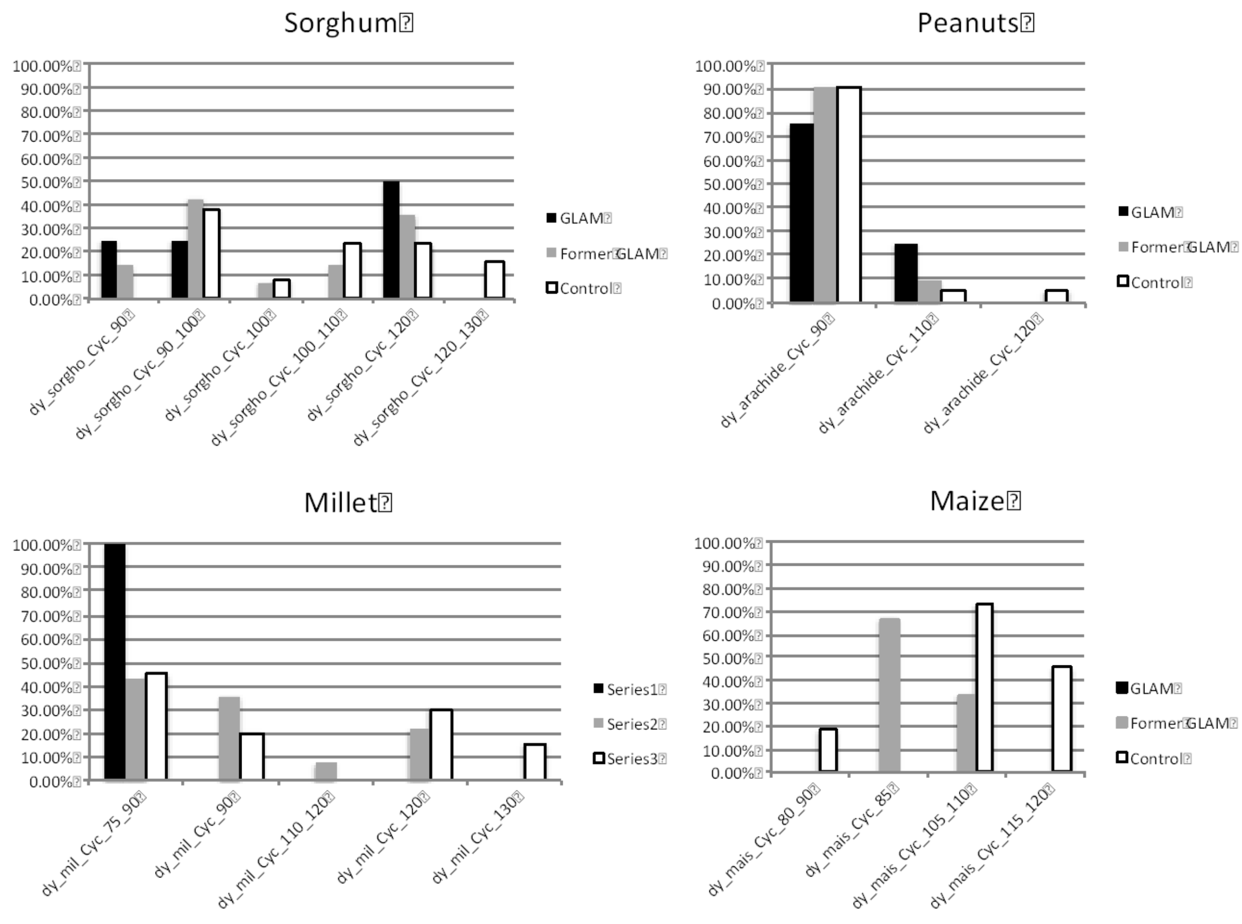



**Figure A10: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types.**

A check of the GLAM junior men shows that there is little difference in variety selection between all GLAM junior men, those who reported using the information, and who accurately reported the working of the program (Figure A11).

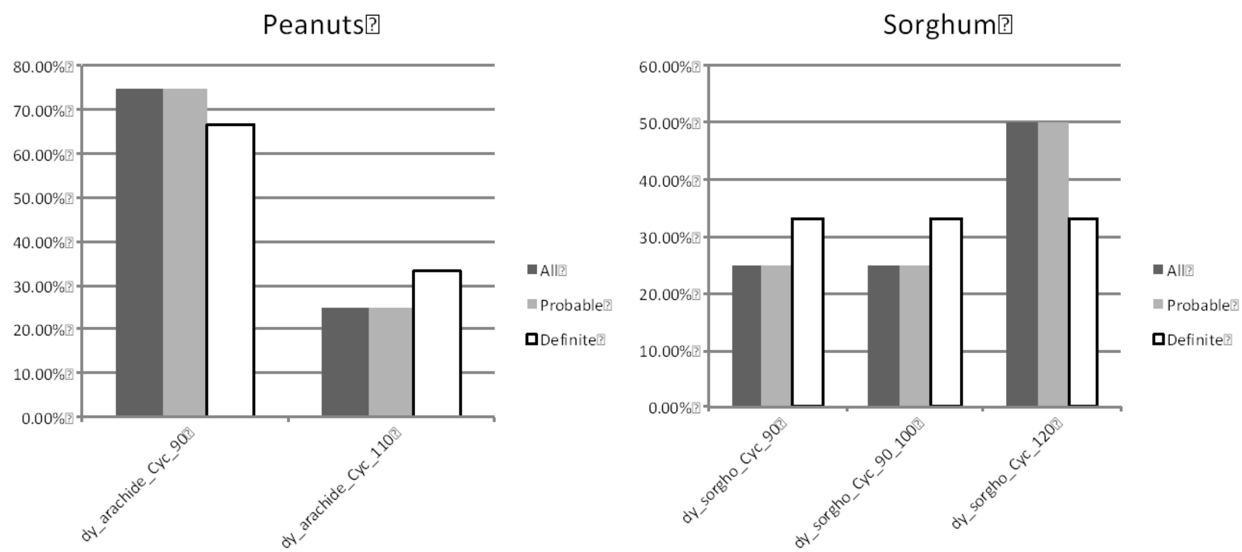



**Figure A11: Comparisons of variety selection among junior men in GLAM villages, comparing all such men, those that reported using the advisories, and those that used the advisories and accurately reported the workings of the program.**

Figure A12, which represents the intended uses of the crops on junior men's farms, points to a major difference in strategy between those in GLAM villages and those in both former GLAM and control villages. The junior men living in GLAM villages were much more market oriented in their agricultural production. They viewed henna and sesame as cash crops, and peanuts as more for sale than subsistence. All of these crops appear on 80% of these men's farms, suggesting that the typical junior man in a GLAM village plants between two and three crops for sale, with the balance aimed at subsistence. For the junior men in the other villages, nearly all market engagement comes from the sale of surplus staple production. While some crops aimed at market sale appeared on the farms of junior men in control villages, excluding sesame they appear on 13% of these farms or less, making them minor crops. This is a very different approach to agricultural production than seen in the GLAM village. It is not clear if this difference in agricultural strategy is an effect of exposure to the advisories, or a reason that the GLAM village was selected for participation in the agrometeorological program in the first place.

**GLAM Junior Man**

| | |
|---|---|
| Sorghum | Eat all |
| Peanut | Sell more than eat |
| Henna | Sell all |
| Millet | Eat all |
| Sesame | Sell all |
| Fonio | Eat and sell equally |

**Former GLAM Junior Man**

| | |
|---|---|
| Sorghum | Eat more than sell |
| Millet | Eat more than sell |
| Peanut | Eat more than sell |
| Cowpeas | Eat more than sell |
| Fonio | Eat more than sell |
| Rice | Eat all |
| Maize | Eat all |
| Sesame | Eat all |
| Cotton | Sell all |
| Roselle | Eat all |

**Control Junior Man**

| | |
|---|---|
| Millet | Eat all |
| Peanut | Eat more than sell |
| Sorghum | Eat more than sell |
| Fonio | Eat all |
| Maize | Eat all |
| Sesame | Sell more than eat |
| Cowpeas | Eat more than sell |
| Henna | Sell all |
| Cotton | Sell all |
| Watermelon | Sell all |
| Rice | Eat all |
| Bambara nuts | Sell more than eat |
| Roselle | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A12: Intended uses of all crops on two or more junior men's farms for cluster 1.**

The agricultural strategies of junior men in GLAM villages in cluster 1 were aggressively oriented toward market production, more so than among any other group in the cluster. These men did hedge their production to a degree by mixing in staple crops that they used to meet subsistence needs, as well as staples that they used for both subsistence and market sale depending on needs and market conditions. Junior men in former GLAM and control villages were much more conservative, focused on subsistence-first production strategies that allowed for market sale if they produced a surplus. Sorghum and peanut production were also likely tied to livestock husbandry. A large majority of junior men in all villages owned livestock (cattle, goats, and sheep were the most common) and may have been using some of their sorghum production, and the post-harvest residues of peanut plants, to feed animals.

While different in their orientation toward markets, both the aggressive market orientation of junior men in GLAM villages and the more conservative orientation of agricultural production associated with junior men in former GLAM and control villages rested on problematic variety selection strategies. Unless there were significant community-level risk sharing mechanisms in place (this is not clear), all farmers in this sample were exposed to climate variability because of their single variety selection strategies.

Senior women

No senior woman claimed to be using the advisories to inform her agricultural practices. Therefore, it is very unlikely they are using the program. However, there is evidence that they were indirectly benefiting from the program by following the advice of their husbands and sons, or by following the practices of those who used the advisories without formally engaging with the program.

The average senior women in a GLAM village grew nearly 7 crops, more than in either former GLAM (4.1 crops) or control (3.9 crops) villages (Figure A13). These women had the highest average number of crops of any cohort in this cluster, while those in former GLAM and control villages had averages close to those for both junior and senior men in their villages. This increased average number of crops appears to be the product of the fact that over 80% of senior women in GLAM villages participated in gardening, which opened up the opportunity to raise a wide variety of crops. Only roughly 25% of women in former GLAM and control villages gardened.

A greater proportion of senior women in GLAM villages grew sorghum, peanuts, and sesame than in former GLAM or control villages. However, in all settings peanuts were the most commonly mentioned crop of senior women. There is no millet on the farms of senior women in GLAM villages, while 1/3 of those living in former GLAM villages, and half of those in control villages, raise millet. Sorghum was also raised by more senior women in GLAM villages than in any other village type.

**GLAM Senior Woman**

| | |
|---|---|
| Avg # crops | 6.8 |
| Peanut | 100.00% |
| Okra | 83.33% |
| Tomato | 83.33% |
| Cowpeas | 66.67% |
| Sesame | 66.67% |
| Sorghum | 66.67% |
| Lettuce | 33.33% |
| Melon | 33.33% |
| Hibiscus | 33.33% |
| Eggplant | 16.67% |
| Cabbage | 16.67% |
| Cucumber | 16.67% |
| Maize | 16.67% |
| Watermelon | 16.67% |
| Chili pepper | 16.67% |
| Potato | 16.67% |

**Former GLAM Senior Woman**

| | |
|---|---|
| Avg # crops | 4.1 |
| Okra | 86.67% |
| Peanut | 80.00% |
| Cowpeas | 60.00% |
| Sorghum | 40.00% |
| Millet | 33.33% |
| Tomato | 26.67% |
| Sesame | 26.67% |
| Onion | 13.33% |
| Bambara nuts | 13.33% |
| Hibiscus | 6.67% |
| Chili pepper | 6.67% |
| Fonio | 6.67% |

**Control Senior Woman**

| | |
|---|---|
| Avg # crops | 4.0 |
| Peanut | 60.87% |
| Cowpeas | 60.87% |
| Millet | 52.17% |
| Okra | 43.48% |
| Sorghum | 30.43% |
| Tomato | 21.74% |
| Fonio | 21.74% |
| Bambara nuts | 17.39% |
| Sesame | 13.04% |
| Henna | 13.04% |
| Papaya | 13.04% |
| Lettuce | 8.70% |
| Hibiscus | 8.70% |
| Maize | 8.70% |
| Chili pepper | 8.70% |
| Mint | 8.70% |
| Banana | 4.35% |
| Onion | 4.35% |
| Rice | 4.35% |

**Figure A13: The crop selection preferences of senior women in cluster 1.**

Figure A14 shows the variety selections of senior women in this cluster. At the community level, senior women in GLAM villages focus on shorter cycle varieties of peanuts than in other villages, a selection that mirrors the short-cycle focus seen in both junior and senior men, strongly suggesting that men, whether husbands or sons caring for their mothers, greatly shape the variety selections of women. Their sorghum variety selection also maps very closely to that of senior men in the cluster, which suggests that most of the women interviewed in this cohort were married and not widows dependent on their sons for land or seeds. Individually, however, senior women in all villages, regardless of exposure to advisories, were planting a single variety of each GLAM crop they cultivated. This increased their individual risk with regard to seasonal climate variability, and as these selections appear to mirror those of men in their villages, likely means that entire households were focusing on single varieties and exposing themselves to significant risk.

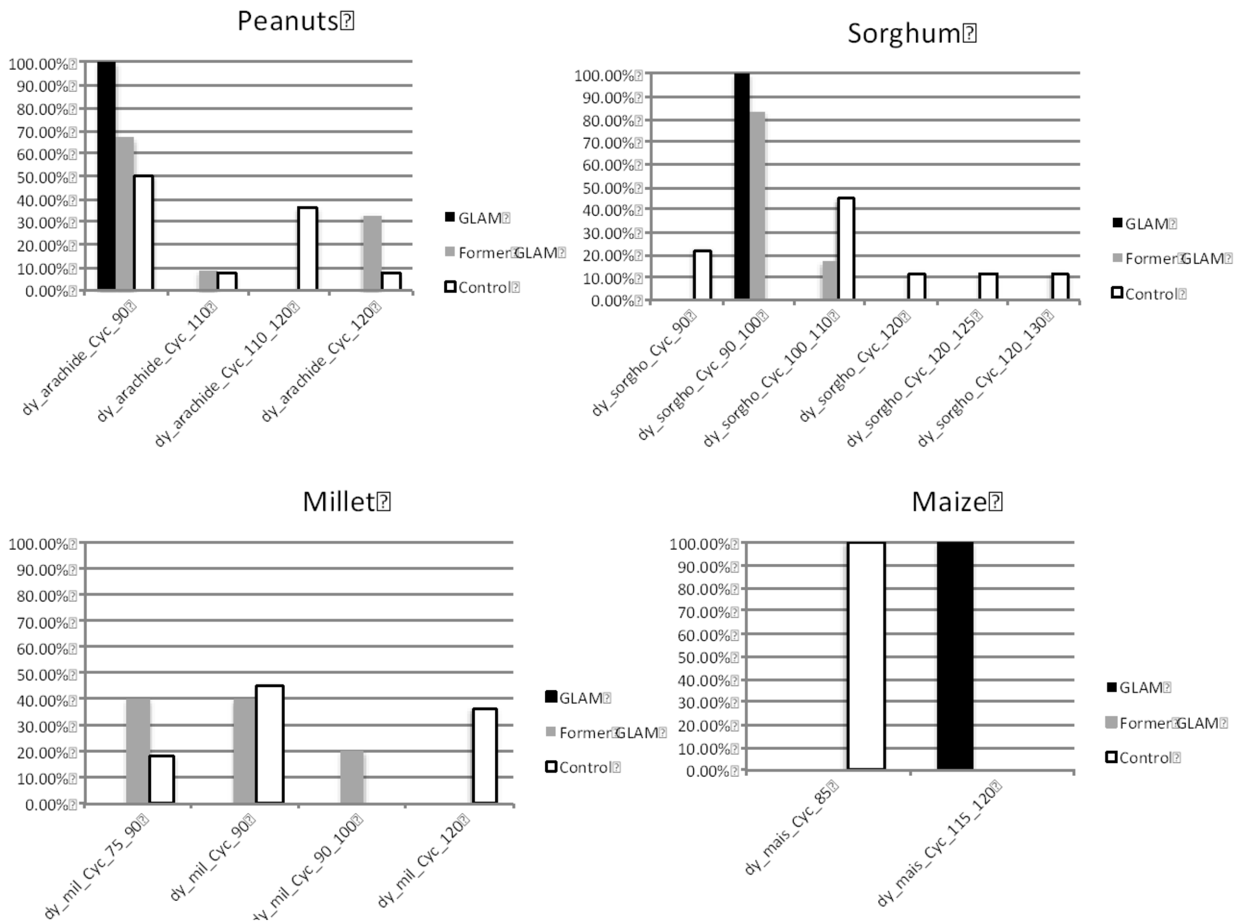



**Figure A14: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types. Note: maize is cultivated by only one senior women in a GLAM village, and only two women in control villages, making it difficult to determine the significance of the differences represented here.**

Figure A15 illustrates that the agricultural production of senior women in GLAM villages was highly oriented toward market production. They raised a cash crop (sesame) and several other crops (lettuce, eggplant, cabbage, and watermelon) principally for market sale. These women expected marketable surpluses from the rest of their staple crops, with the only major exceptions being sorghum and cowpeas. The greater number of senior women in GLAM villages raising sorghum is likely explained by the fact that these women participate in livestock husbandry at around twice the frequency of their former GLAM and control counterparts. In former GLAM and control villages, senior women plant their crops for subsistence first, and market any surplus.  While a few crops in both former GLAM and control villages are planted with the intent of selling at least some of that production from the outset, each of these crops appear on less than a quarter and, in most cases, on less than 10% of these farms, making them marginal parts of a broadly conservative agricultural strategy. In short, in both former GLAM and control villages, senior women seemed to be far less optimistic about their farm production.  The uses that senior women in GLAM villages listed for their crops presumed more, and larger, marketable surpluses than their former GLAM or control counterparts.

**GLAM Senior Woman**

| | |
|---|---|
| Peanut | Eat and sell equally |
| Okra | Eat more than sell |
| Tomato | Eat and sell equally |
| Cowpeas | Eat all |
| Sesame | Sell all |
| Sorghum | Eat all |
| Lettuce | Sell more than eat |
| Melon | Eat and sell equally |
| Hibiscus | Eat more than sell |
| Eggplant | Sell more than eat |
| Cabbage | Sell more than eat |
| Cucumber | Eat more than sell |
| Maize | Eat all |
| Watermelon | Sell more than eat |
| Chili pepper | Eat all |
| Potato | Eat more than sell |

**Former GLAM Senior Woman**

| | |
|---|---|
| Okra | Eat more than sell |
| Peanut | Eat more than sell |
| Cowpeas | Eat more than sell |
| Sorghum | Eat more than sell |
| Millet | Eat more than sell |
| Tomato | Eat and sell equally |
| Sesame | Sell more than eat |
| Onion | Eat and sell equally |
| Bambara nuts | Eat all |
| Hibiscus | Eat and sell equally |
| Chili pepper | Eat more than sell |
| Fonio | Eat all |

**Control Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Cowpeas | Eat more than sell |
| Millet | Eat more than sell |
| Okra | Eat more than sell |
| Sorghum | Eat more than sell |
| Tomato | Eat more than sell |
| Fonio | Eat all |
| Bambara nuts | Eat all |
| Sesame | Eat more than sell |
| Henna | Sell all |
| Papaya | Sell more than eat |
| Lettuce | Eat and sell equally |
| Hibiscus | Eat all |
| Maize | Eat all |
| Chili pepper | Sell more than eat |
| Mint | Sell all |
| Banana | Sell more than eat |
| Onion | Sell more than eat |
| Rice | Eat all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A15: Intended uses of all crops on two or more senior women's farms for cluster 1.**

Senior women had a major role in providing basic subsistence for their households. However, those in GLAM villages added at least one crop intended principally for market sale to their otherwise conservative mix, and generally viewed their crops overall as likely to yield a marketable surplus. These two crops may be more subsistence oriented than the others because of their role as fodder for animals, which these women owned at a much higher rate than in other villages. It is worth noting that senior women in GLAM villages had much more diversified livelihoods than their control counterparts.  In GLAM villages, they participated in livestock husbandry, picking/gathering, and wood cutting at more than twice the rate seen in former GLAM or control villages. Women in GLAM and former GLAM villages had much higher rates of participation in market/business activities than those in control villages. These diversified livelihoods and market-oriented agricultural efforts might explain why senior women in GLAM villages did not list hunger as a major challenge, suggesting that they were much more able to manage their food shortages each year, whether through a larger supply of food, greater reserves of income, or enhanced capacity to access loans to get them through the hungry season.

Junior women

No junior women in GLAM villages in cluster 1 claimed to be using the advisories to inform their agricultural practices. As with senior women, however, it is possible that they are indirectly benefiting from the program by following the advice of their husbands and sons, or by following their practices without being advised.

The average junior women's farm in a GLAM village contained 5.2 crops, larger than the 2.6 on the average farm of her counterpart in a former GLAM village and the 2.1 on the average farm of her control counterpart (Figure A16). This crop selection pattern reflects the fact that those junior women engaged in gardening, an activity that multiplies the number of crops grown by a given farmer, were nearly exclusively found in GLAM villages. Peanuts were the most commonly grown crop for junior women across the cluster, though the percentage of junior women growing peanuts was substantially larger in GLAM villages than in either former GLAM or control villages. A much larger percentage of junior women in GLAM villages also grew sorghum than in other villages. While millet production was generally uncommon among junior women, it is nonexistent among those living in GLAM villages. All junior women in GLAM villages reported growing the cash crop sesame, where it appeared on at most 16% of the farms in former GLAM and control villages.

**GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 5.2 |
| Peanut | 100.00% |
| Okra | 100.00% |
| Sesame | 100.00% |
| Tomato | 80.00% |
| Sorghum | 60.00% |
| Cowpeas | 40.00% |
| Eggplant | 20.00% |
| Lettuce | 20.00% |

**Former GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 2.6 |
| Peanut | 66.67% |
| Okra | 53.33% |
| Cowpeas | 33.33% |
| Tomato | 26.67% |
| Sorghum | 26.67% |
| Millet | 26.67% |
| Sesame | 13.33% |
| Onion | 13.33% |

**Control Junior Woman**

| | |
|---|---|
| Avg # crops | 2.0 |
| Peanut | 48.00% |
| Okra | 32.00% |
| Millet | 32.00% |
| Cowpeas | 24.00% |
| Sesame | 20.00% |
| Onion | 20.00% |
| Tomato | 12.00% |
| Chili pepper | 8.00% |
| Maize | 4.00% |
| Mint | 4.00% |

**Figure A16: The crop selection preferences of junior women in cluster 1.**

Figure A17 illustrates the variety selection, by cycle length, of junior women in cluster 1. Across village types these women were selecting the same cycle of peanuts as both senior and junior men, as well as senior women. In GLAM villages, junior women's variety selections for sorghum were longer-cycle than in former GLAM villages (junior women in control villages did not raise sorghum). This selection closely resembles that of junior men, suggesting that these women are married and likely responding to the variety selections of their husbands. Those in former GLAM villages closely mirror the sorghum variety selections of junior men as well. We cannot assume that all variety selections were determined by men. Millet selections for junior women in former GLAM and control villages (no junior women in GLAM villages reported growing millet) did not resemble the selections of junior or senior men. Whether this pattern of variety selection as a product of women making independent decisions about the varieties they planted is unclear.

The variety selections of junior women displayed limited diversification across cycles at the community level. However, without a definitive risk-sharing mechanism at the community level, the single-variety selection strategy of these women exposed their production to shocks and seasonal climate variability.

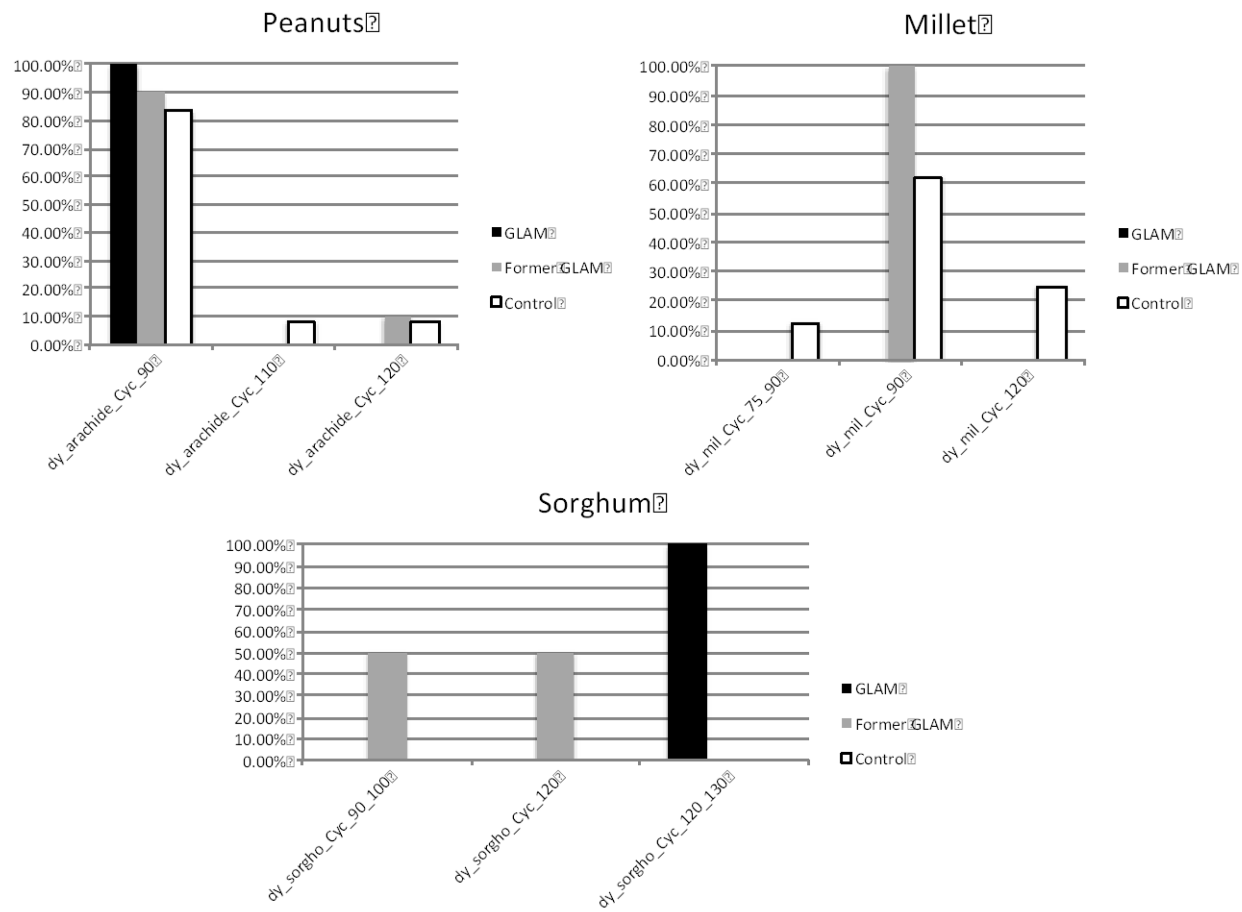



**Figure A17: Charts representing variety selection for the three advisory-informed crops for which there were significant differences in variety selection across the village types.**

Figure A18, which illustrates the intended uses of these crops for junior women in both GLAM and control villages, demonstrates that there were two different strategies for making a living among junior women in this cluster. Overall, junior women in GLAM villages grew a cash crop (sesame) and another crop (peanuts) with the expectation of obtaining a marketable surplus. Everything else they raised was for subsistence. In both former GLAM and control settings, junior women were apparently optimistic about these crop yields, as they expected marketable surpluses from all of them. While there were clearly cash crops (i.e., tomato and sesame) on the farms of junior women in former GLAM and control villages, these crops were farmed by 25% or less (often much less) of the sample and therefore do not constitute core components of the agricultural strategy of these women.

**GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Okra | Eat all |
| Sesame | Sell more than eat |
| Tomato | Eat all |
| Sorghum | Eat all |
| Cowpeas | Eat all |
| Eggplant | Eat all |
| Lettuce | Sell more than eat |

**Former GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Okra | Eat more than sell |
| Cowpeas | Eat and sell equally |
| Tomato | Sell all |
| Sorghum | Eat more than sell |
| Millet | Eat more than sell |
| Sesame | Sell all |
| Onion | Sell more than eat |

**Control Junior Woman**

| | |
|---|---|
| Peanut | Eat and sell equally |
| Okra | Eat more than sell |
| Millet | Eat more than sell |
| Cowpeas | Eat more than sell |
| Sesame | Sell all |
| Onion | Sell more than eat |
| Tomato | Sell more than eat |
| Chili pepper | Eat and sell equally |
| Maize | Eat all |
| Mint | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A18: Intended uses of all crops on two or more junior women's farms, in GLAM, former GLAM, and control villages, for cluster 1.**

Understanding the differences in agricultural strategy among junior women in this cluster requires placing agriculture into the wider suite of livelihoods activities undertaken by these women. While agriculture might have been the most common activity among junior women, it plays different roles for these women depending on where they live. Junior women in GLAM villages diversified their livelihoods in many ways, including livestock husbandry, trade, picking and gathering, and gardening. Agriculture was therefore not as much the most important activity as a complementary component of a suite of important livelihoods activities. Junior women in GLAM villages did not mention any concerns with obtaining adequate animal fodder, suggesting that their cultivation of peanuts and sorghum served to meet both the need for food and fodder, as they raised livestock at twice the rate of their former GLAM and control counterparts. Junior women in GLAM villages spread their livelihoods across a wider range of activities than their control counterparts, which might have created greater resilience in their livelihoods, especially when those activities included shoring up the subsistence base of the household by cutting wood for firewood and gathering fruits and wild plants. In former GLAM and control villages, however, agriculture was clearly the most important activity, and appeared to be a significant source not only of subsistence, but also of income.

### 6.2.4. CLUSTER 1 SUMMARY

There is very limited evidence to support the claim that advisories impact the agricultural decisions of farmers in this cluster. Women do not claim to use the advisories at all. While a large percentage of the men in the GLAM village do seem to be using the advisories, the differences in crop selection between those in GLAM villages and those without access to the advisories are small, and difficult to attribute with the data at hand. There is a clear pattern of those in GLAM villages de-emphasizing millet, and focusing on sorghum, that is interesting and could be tied to advisories, but may also have much to do with livestock husbandry. Within GLAM villages, there is very little difference in the crop selections of those using the advisories and those that are not.

The analysis of variety selection suggests only small, irregular differences between the selections of those in GLAM villages and those in other villages, with maize (a relatively unimportant crop in this cluster) and peanuts showing the only real evidence of different selection. Within GLAM villages, there was no difference between the variety selections of all men and those using the advisories. However, it appears that the farmers in this cluster who used the advisories applied them consistently to their agricultural practices. However, the data at hand does not allow us to separate the influence of the advisories from other constituents of variety selection (i.e., the need for animal fodder at particular times of the year, or the desire to time markets for maximum pricing). The heavy emphasis on livestock husbandry in the livelihoods of cluster 1 requires fodder, which means that in the case of peanuts and sorghum crop selections, as well as variety selections, are likely selected to meet both food and fodder needs that cannot shift easily on a seasonal basis.

There are also clearly gendered barriers to program impact related to the advisories. Because the agrometeorological advisories delivered by the program target five crops, maize, millet, cotton, sorghum, and peanuts, those who grow these crops are going to be those who derive the most direct benefit from the program. In cluster 1, women grow these crops less frequently than men, and therefore will derive less benefit from such advisories. Further, to benefit from the advisories, farmers must also have the capacity to act upon the advisories. Women may not be able to use the advisories directly, but their production, crop selections, and variety selections are clearly tied to men's decisions. Therefore, women in GLAM villages are at best indirect users of the advisories.

There are clearly different livelihoods strategies at work in this cluster that are correlated with access to the advisories. Those living in the GLAM village are clearly more market-oriented in their agricultural production, and their livelihoods on the whole. It is impossible to determine if this is an outcome of participation in the program, or if this was a preexisting characteristic of this community that led to its selection for participation in the program.

Finally, there is a disturbing pattern of variety selection taking place in this cluster. At the level of the individual farmer, nearly all farmers, regardless of village, are focusing on a single variety of the GLAM crops they cultivate. While this practice heightens agricultural risk in all villages by focusing on a single cycle length in a variable climate regime, in GLAM villages men who follow the advisories are particularly vulnerable to incorrect seasonal forecasts. This suggests an immediate need to better communicate probability and uncertainty to farmers in this cluster generally, and especially around the agrometeorological advisories.

To summarize, the only likely impacts of the advisories seen in cluster 1 are:

1) Crop selection
    a. Those in the GLAM village de-emphasized millet on their farms relative to their counterparts in former GLAM and control villages. This was true across all cohorts.
        i. There are no other clear explanations for such de-emphasis beyond seasonal advisories.
        ii. Further, the fact that former GLAM farmers raised millet at a rate similar to that in control settings provides further circumstantial support for this difference in crop selection being a seasonal decision.
    b. As nearly all men interviewed in GLAM villages reported using the advisories to shape their agricultural strategies, it is possible that the advisories shaped this crop selection pattern.
2) Variety Selection
    a. With the exception of peanuts, all variety selections by junior and senior men in GLAM villages are consistent with the advisories. Circumstantially, the fact that the variety selections of maize and millet by junior and senior men in GLAM villages closely resemble one another, and are dissimilar to those in either former GLAM or control villages, suggests that the advisories likely guided variety selection for GLAM men as the season unfolded. The shorter-cycle peanut selections of GLAM men are likely related to specific market and fodder goals more focused on the timing of the harvest than the overall amount harvested.
    b. As nearly all men interviewed in GLAM villages reported using the advisories to shape their agricultural strategies, these selections are probably related to advisories. However, if this is the case the resultant focus on a single cycle should be examined and corrected.
3) Agricultural strategy
    a. Those in GLAM villages have a greater orientation toward market sale for their crops than their counterparts in former GLAM and control villages.
        i. They plant crops that are explicitly for sale, such as sesame, at greater rates than in the other villages
        ii. They appear to have more confidence in producing surpluses of staple crops that could then be marketed.
        iii. They have more diversified livelihoods
        iv. This overall focus may reflect the use of, and confidence in, the advisories, but it must be determined if this is an outcome of program participation or a preexisting condition that led this community to be selected for participation.

<u>Provisional decision-making model to inform future design</u>

In cluster 1, livelihoods are framed around agriculture and livestock husbandry, with business/trade and other activities as contributing components of livelihoods. Most agricultural strategies incorporate a hedge against variable rainfall, as the most commonly planted crops are those that can be eaten by the household, but sold if there is a surplus. Livestock are a critical component of these livelihoods, and agricultural decisions take into account the need for fodder, as well as the food and income needs of the household until such time as alternative sources of adequate fodder might be found. Further, these strategies appear to hold market engagement at arm's length. The near-absence of cotton on these farms, and the fact that these farms combine the limited cultivation of sesame (a cash crop) with a heavy emphasis on staple cropping, strongly supports this hypothesis, as it seems that farmers are happy to earn income from cash crops, but seeking to avoid situations in which they become dependent on agriculture-derived cash income alone. It is unclear if this aversion to market engagement stems from concerns with the local climate, markets, or a combination of the two.

In cluster 1, women control trade, which is considered a "woman's activity" in this cluster. Gardening is also a woman's activity in this cluster. This gendering, likely related to the expectation that men feed their families through rain-fed agriculture, suggests that men are unlikely to shift from the cultivation of rain-fed grains into irrigated gardening easily should precipitation patterns become less favorable for rain-fed agriculture. In any case, when we consider men's and women's reported challenges in this cluster, we find that both men and women, whether junior or senior, ranked irregular rainfall among their top two concerns. This suggests that gardening provides only a small buffer for women's agricultural production in this cluster, and therefore might not be a useful adaptation option in the future.

Among women, junior women are less likely to participate in gardening or gathering/picking. Instead, they seem to concentrate their efforts in agriculture, trade, and animal husbandry. It appears that junior women are more focused on obtaining cash incomes than senior women, who appear to be somewhat more subsistence-focused. It is not clear if this difference is a product of different livelihoods strategies or different capacities to engage in these activities. Among men, junior men are more likely to take on miscellaneous jobs and work in handicrafts, while senior men are more engaged in animal husbandry. It is not clear if this reflects different attitudes toward making a living, stages in the life-course where junior men have not yet accumulated the capital to focus on livestock husbandry as a secondary livelihoods activity, or a situation where junior men are simply more mobile and able to move to this sort of work more easily than their senior counterparts.

## 6.3. CLUSTER 2: ML12: "SOUTH WEST MAIZE, SORGHUM, AND FRUITS"


**Location of the livelihoods zone to which Cluster 2 villages belong. Source: Dixon and Holt, 2010, p.109.**

### 6.3.1. VULNERABILITY CONTEXT

The four villages in cluster two are located in the Southeast corner of the Sikasso Region (no villages in the assessment were located in the western part of this zone). Located in perhaps the most agriculturally productive environment in the country, farms in these villages receive between 1000-1300cm of rain each year. Nearly all annual rain falls between May and October, with the heaviest rains between the beginning of July and the end of August. The sandy clays and gravelly soils of this zone are relatively fertile, and the topography includes localized depressions that trap moisture and provide water and agricultural resources beyond the rainy season (Dixon & Holt, 2010, p.109-111).

The length and amount of annual rains results in a hungry season in July and August. This is somewhat mitigated for wealthier households by the consumption and sale of milk from their cattle. Poorer households collect shea nuts at this time, and use the income from their sale to enable staple food purchases (Dixon & Holt, 2010, p.111). Dixon and Holt (2010, p.111) note different patterns of livestock use, where wealthier households sell off livestock ahead of the rainy season to facilitate agricultural investment, while poorer households sell off their livestock (primarily poultry) during the hungry season to meet household needs. This suggests that the poultry owned by poorer households are not adequate sources of investment capital for agriculture and that poorer households lack confidence in their harvests that might prompt them to sell their animals and invest heavily in agricultural materials, or both.

According to Dixon and Holt (2010, p.109-110), farmers in this region produce fruits for export, either whole or as juice. This activity is concentrated among the wealthiest in society. While a significant source of income, this engagement also exposes these households to market instability, especially in the context of recent border closings resulting from political instability in Mali and neighboring countries. Cotton is the other major cash crop grown in this region. Because its production and sale are heavily controlled by CMDT, farmer income from this crop is more directly affected by political instability and changing state capacity than fruit incomes. The general tracing of market pathways by Dixon and Holt (2010, p.110) suggests that in this part of the zone, the bulk of marketed agricultural production goes to Bamako.[8] Poultry are also sent to Bamako, while other livestock go both to Bamako and across the border to Cote d'Ivoire.

Dixon and Holt (2010, p.115) recorded several challenges in this zone. While rainfall amounts were less problematic in this part of Mali than in others, rainfall variability was a significant issue. Flooding, crop pests, and unstable prices for agricultural inputs were also significant. Farmers complained about late payments for their cotton from CMDT, and expressed concern over livestock disease and livestock theft. Figure A19 lists the livelihoods challenges identified by the field assessment team via focus groups in this cluster, and their relative importance to the members of that group. As such, it moves beyond the aggregated vulnerability context of Dixon and Holt (2010) to present different experiences of the vulnerability context tied to the social positions of different residents. One of the broad issues identified in the FEWS-NET report, lack of access to adequate inputs, was listed as a challenge by every cohort in every village, and generally was the second or third most important challenge faced by that cohort. Lack of access to farming equipment was mentioned by nearly all cohorts in all villages, just behind access to inputs. However, all of the other major challenges were identified and prioritized differently between cohorts and villages. Of note is the fact that variable rainfall appears to be a larger issue for men than women, and more of a concern in GLAM villages than in other settings. The concern for water availability is also mixed in this cluster, where senior men appear to be less concerned about this issue than other cohorts. Concerns over cattle disease appeared only in control villages, and were not ranked as the most important concern. It is clear from this figure that the experience of the vulnerability context is related to gender and seniority, as well as to the village in which one lives.

[8] In western parts of this zone, agricultural goods appear to move to Senegal and Guinea, as well as to Bamako. This is a very unlikely pathway for crops in these sample villages, as they are at the opposite end of the country, with Bamako as an intervening market opportunity.

| Junior Men | GLAM average | Former GLAM average | Control Average |
|---|---|---|---|
| Water availability | 1 | | 1 |
| Irregular/inadequate rainfall | 1 | | |
| Lack of inputs | 2 | 3 | 1.5 |
| Market problems | 2 | | |
| Land cover and soil degradation | 3 | | |
| Lack of farming equipment | 4 | 2 | 3 |
| Transportation infrastructure | | 1 | |
| Illness | | | 1 |
| Forest degradation | | | 3 |
| Lack of veternarian | | | 4 |
| Lack of animal fodder | | | 5 |

| Senior Men | GLAM average | Former GLAM average | Control Average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1 | 1 | |
| Lack of farming equipment | 2 | | 2 |
| Land cover and soil degradation | 2 | | 1 |
| Lack of inputs | 2.5 | 2 | 1 |
| Low access to land | 3 | | |
| Water availability | | 3 | |
| Transportation infrastructure | | 4 | |
| Lack of good seeds | | | 2 |
| Lack of veternarian | | | 3 |

| Junior women | GLAM average | Former GLAM average | Control Average |
|---|---|---|---|
| Lack of farming equipment | 1 | | 2 |
| Lack of inputs | 2 | 1 | 1 |
| Water availability | | 2 | 3 |
| Lack of animal fodder | | 3 | |

| Senior women | GLAM average | Former GLAM average | Control Average |
|---|---|---|---|
| Water availability | 1 | 1 | |
| Lack of farming equipment | 1.5 | 3 | 3 |
| Lack of inputs | 2.5 | 1.5 | 2 |
| Market problems | | 2 | |
| Irregular/inadequate rainfall | | | 1 |
| Cattle disease | | | 4 |

**Figure A19: Principal livelihoods challenges, as reported by focus groups in cluster 2.**

### 6.3.2. LIVELIHOODS IN CLUSTER 2

Agriculture was by far the dominant livelihoods activity in the four villages of Cluster 2 (Figure A20). While every interviewee in this cluster (N=100) participated in agriculture, only about 1/3 participated in trading or livestock husbandry, the next most common activities. About 20% of the interviewees reported cutting trees, mostly for firewood for household use or sale.

Several livelihoods activities in this cluster had both seniority and gender associations. Women largely dominated trading and exclusively practiced wood-cutting and gathering, with the latter concentrated among junior women in the control village.  Men, especially senior men, had the highest rates of participation in livestock husbandry, though the difference between junior men and women was much less pronounced than that between senior men and women.

| | GLAM senior man (N=12) | Former GLAM senior man (N=7) | Control Senior Man (N=12) | GLAM Senior Woman (N=10) | Former GLAM senior Woman (N=5) | Control Senior Woman (N=9) | GLAM Junior Man (N=9) | Former GLAM Junior Man (N=3) | Control Junior Man (N=8) | GLAM Junior Woman (N=10) | Former GLAM Junior Woman (N=5) | Control Junior Woman (N=10) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| Business | 8.33% | 0.00% | 16.67% | 40.00% | 60.00% | 22.22% | 0.00% | 33.33% | 12.50% | 90.00% | 80.00% | 50.00% |
| Livestock | 75.00% | 28.57% | 66.67% | 30.00% | 20.00% | 0.00% | 44.44% | 0.00% | 12.50% | 20.00% | 0.00% | 30.00% |
| Other | 16.67% | 14.29% | 0.00% | 0.00% | 20.00% | 55.55% | 22.22% | 0.00% | 0.00% | 0.00% | 40.00% | 20.00% |
| Logging | 0.00% | 0.00% | 0.00% | 50.00% | 0.00% | 44.44% | 0.00% | 0.00% | 0.00% | 40.00% | 0.00% | 20.00% |
| Gathering/ picking | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 80.00% |
| Gardening | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 37.50% | 10.00% | 0.00% | 0.00% |

**Figure A20: Livelihoods activities in cluster 2.**

Given these different livelihoods emphases, we can identify different potential vulnerabilities within these livelihoods. Men were heavily exposed to variable precipitation and water shortage, as their livelihoods nearly exclusively depended on rain-fed agriculture and adequate forage and pastureland for their livelihoods regardless of where they lived. In general, women were more heavily engaged in trade than men. This group was exposed to market instability related to changes in urban incomes, especially those in Bamako. Woman were also clearly responsible for collecting firewood for their households, and at least in some cases for selling that wood. It is unlikely that this activity would be negatively impacted by either climate or economic shocks, though long-term climate-related environmental change could reduce the trees available for cutting/gathering.

### 6.3.3. AGRICULTURE IN CLUSTER 2

Farmers in cluster 2 grew 19 main crops (Table A2). Of these crops, eight (cotton, fonio, cassava, cowpeas, papaya, sweet potato, potato, and sorghum) were men's crops, and men also dominated the production of millet. Therefore, three GLAM crops were the exclusive province of men. Both men and women grew maize and peanuts, the other two crops for which there are advisories. The men of cluster 2 grew far more of the crops for which there were advisories, and therefore the advisories had greater potential use for them than they do for women. In cluster 2 there were four crops that could be classified as principally women's crops. All were crops commonly found on gardens, and none were very commonly gardened. This makes sense, as only three farmers in this cluster, all junior men in control villages, reported gardening as a livelihoods activity. Therefore, in this cluster women were not as engaged with hand irrigation in their gardening and agricultural work as in other clusters, and therefore experienced exposure to the challenges of rain fed agriculture in a manner similar to their husbands.

| | GLAM senior man | Former GLAM senior man | Control Senior Man | GLAM Senior Woman | Former GLAM senior Woman | Control Senior Woman | GLAM Junior Man | Former GLAM Junior Man | Control Junior Man | GLAM Junior Woman | Former GLAM Junior Woman | Control Junior Woman |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg # crops | 4.4 | 3.7 | 4.1 | 1.4 | 2.2 | 1.7 | 3.1 | 4.3 | 5.1 | 1.9 | 1.2 | 1. |
| Peanut | 16.67% | 14.29% | 0.00% | 20.00% | 20.00% | 0.00% | 0.00% | 66.67% | 0.00% | 30.00% | 40.00% | 0.00% |
| Eggplant | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 0.00% |
| Cabbage | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 0.00% |
| Cotton | 100.00% | 42.86% | 0.00% | 0.00% | 0.00% | 0.00% | 77.78% | 33.33% | 0.00% | 0.00% | 0.00% | 0.00% |
| Fonio | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Ginger | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 11.11% | 0.00% | 0.00% | 75.00% | 0.00% | 0.00% | 40.00% |
| Okra | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 37.50% | 20.00% | 0.00% | 40.00% |
| Maize | 100.00% | 100.00% | 91.67% | 10.00% | 40.00% | 44.44% | 100.00% | 100.00% | 100.00% | 0.00% | 20.00% | 0.00% |
| Cassava | 0.00% | 0.00% | 25.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 25.00% | 0.00% | 0.00% | 0.00% |
| Millet | 75.00% | 100.00% | 58.33% | 0.00% | 40.00% | 0.00% | 44.44% | 100.00% | 75.00% | 0.00% | 0.00% | 0.00% |
| Cowpeas | 0.00% | 0.00% | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Papaya | 8.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Sweet potato | 16.67% | 0.00% | 41.67% | 0.00% | 0.00% | 0.00% | 11.11% | 0.00% | 37.50% | 0.00% | 0.00% | 0.00% |
| Chili pepper | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 0.00% |
| Sweet peas | 0.00% | 57.14% | 0.00% | 0.00% | 20.00% | 11.11% | 0.00% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% |
| Potato | 8.33% | 0.00% | 33.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 62.50% | 0.00% | 0.00% | 0.00% |
| Rice | 33.33% | 28.57% | 58.33% | 100.00% | 80.00% | 100.00% | 11.11% | 66.67% | 50.00% | 100.00% | 40.00% | 100.00% |
| Sorghum | 83.33% | 28.57% | 66.67% | 10.00% | 20.00% | 0.00% | 66.67% | 66.67% | 50.00% | 0.00% | 0.00% | 0.00% |
| Tomato | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 0.00% |

| | |
|---|---|
| Onion | Women's crop |
| Rice | Men's crop |
| Sorghum | Crop targeted by the agromet program |

**Table A2: All crops grown in cluster 2, by subgroup and GLAM/former GLAM/control village.**

Senior Men

In cluster 2, only one third (n=4) of the senior men in GLAM villages reported using the advisories. All of these men demonstrated an understanding of how the program worked, and therefore it is likely that this accurately represents the number of senior men actually using the advisories in this sample.

The average senior men living in a GLAM village grew 4.4 crops. His counterparts in former GLAM (3.7 crops) and control (4.1 crops) villages grew only slightly fewer crops. Figure A21 shows the crop selection preferences of senior men in this cluster in GLAM, former GLAM, and control villages. Senior men in both GLAM and former GLAM villages raised all five crops targeted by agrometeorological advisories, while those in control villages only raised three. Four of these crops (cotton, maize, sorghum, and millet) appeared on 75% or more of the farms of senior men in GLAM villages. While maize and millet appeared on all farms in former GLAM villages, cotton, sorghum, and peanuts were much less common than in GLAM villages. In control villages, maize appeared on more than 90% of farms, but sorghum and millet appeared on only about 60% of farms each. Thus, senior men in GLAM villages grew more crops affected by the advisories, and with greater frequency, than in those in either former GLAM or control villages. These crop selections also suggest a difference in agricultural strategy. Cotton was found on all farms in GLAM villages, on less than half of farms in former GLAM villages, and not at all in control villages. Cotton is a cash crop, and its high frequency in GLAM settings suggests that men in this setting were more strongly engaged with market production than their counterparts in former GLAM or control villages. The frequency of sorghum cultivation varied across these village types, but tracked closely to the rate of participation in livestock husbandry. For example, while sorghum was found on relatively few farms in the former GLAM villages, it appeared on exactly the same percentage of senior men's farms as reported owning livestock. In former GLAM villages, senior men emphasize millet cultivation in a manner not seen in the other villages, but the reason for this is not clear. Overall, the structure of crop selection among senior men in cluster 2 suggests that those in GLAM villages were focused on crops for which they receive advisories, those in former GLAM villages might have been gradually phasing out cotton in the absence of advisories, and those in control villages were focused on maize as the key staple, with the rest of their farms distributed across grains and vegetables.

**GLAM senior man**

| | |
|---|---|
| Avg # crops | 4.4 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 83.33% |
| Millet | 75.00% |
| Rice | 33.33% |
| Peanut | 16.67% |
| Sweet potato | 16.67% |
| Papaya | 8.33% |
| Potato | 8.33% |

**Former GLAM senior man**

| | |
|---|---|
| Avg # crops | 3.7 |
| Maize | 100.00% |
| Millet | 100.00% |
| Sweet peas | 57.14% |
| Cotton | 42.86% |
| Sorghum | 28.57% |
| Rice | 28.57% |
| Peanut | 14.29% |

**Control Senior Man**

| | |
|---|---|
| Avg # crops | 4.1 |
| Maize | 91.67% |
| Sorghum | 66.67% |
| Millet | 58.33% |
| Rice | 58.33% |
| Sweet potato | 41.67% |
| Potato | 33.33% |
| Cassava | 25.00% |
| Cowpeas | 8.33% |
| Fonio | 8.33% |
| Ginger | 8.33% |
| Okra | 8.33% |

**Figure A21: The crop selection preferences of senior men in cluster 2, with comparisons between GLAM, former GLAM, and control villages.**

As Figure A22 demonstrates, there is little difference in crop selection between all senior men in GLAM villages and those for whom there is clear evidence of advisory use.

**GLAM Senior Man: All**

| | |
|---|---|
| Avg # crops | 4.4 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 83.33% |
| Millet | 75.00% |
| Rice | 33.33% |
| Peanut | 16.67% |
| Sweet potato | 16.67% |
| Papaya | 8.33% |
| Potato | 8.33% |

**GLAM Senior Man: Definite**

| | |
|---|---|
| Avg # crops | 4.5 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 75.00% |
| Millet | 50.00% |
| Potato | 50.00% |
| Papaya | 25.00% |
| Sweet Potato | 25.00% |
| Rice | 25.00% |

**Figure A22: The crop selections of senior men in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

Figure A23 represents the variety selections of senior men in cluster 2. Senior men in GLAM villages were selecting maize varieties with somewhat shorter cycles than those in former GLAM villages, and at the community level appear to have distributed their selections in a manner that controlled for the uncertainty of seasonal rainfall. Those in control villages emphasized the same cycle duration for maize as those in GLAM villages, but also cultivated somewhat longer cycles. At the community level senior men in GLAM and former GLAM villages distributed their sorghum selections across a wide range of cycles, while those in control villages focused exclusively on the longest cycle varieties. Senior men in GLAM villages were focused on very short cycle millet varieties, with a bit of hedging into longer cycles. Both former GLAM and control villages were focused on longer cycle millet varieties, with those in control villages concentrated on the longest varieties.

The advisories for this cluster, starting in early May, advised the planting of millet, sorghum, maize, and peanut varieties of at least 110 days once local cumulative rainfall reached 10mm for the season. This was lengthened to advise the planting of four to five month (120-150 day) varieties by the third decade of May. While we have no advisories from June, the first July advisory suggested the planting of three-month (90 day) varieties once local rainfall exceeded 10mm, as the season was beginning to run short. This shifting advice suggests an initial assessment of a four to five month rainy season that was later revised down to four months. This shifting advice makes the assessment of advisory impact on farmer decisions difficult. It appears that those using advisories in this cohort largely followed the early advisories for maize and sorghum, picking varieties between 100 and 130 days in length. Millet selection, however, seems to diverge from initial advisories, running to very short cycles. To a lesser extent, sorghum selection follows this same pattern. This fits with a pattern of advisory use. It is possible that farmers planted their maize and sorghum early with the first advisories, as the mid-May advisory suggests that rainfall amounts were normal in this cluster. However, by the time the advisories began to mention the planting of millet, rainfall had dropped below normal levels. By the first July advisory, the rainfall amounts for the decade and for the season have returned to normal levels, but it is not clear when in June that occurred. However, farmers clearly did not plant millet until some point in mid- to late July, forcing them into shorter-cycle varieties.

It appears that, at least for maize and millet, access to the advisories could have influenced the variety selection of senior men. This is harder to say for sorghum, where the patterns may reflect a broader attitude toward risk management brought on by previous experience with the advisories in both GLAM and former GLAM villages, or by fodder needs in these villages that were more focused on the timing of the harvest than the amount harvested. It is again worth noting that, in most cases, individual farmers are focused on a single variety of each crop. Unless there is a risk-sharing mechanism across the community, this means that farmers are highly exposed to uncertainty in the forecasts.

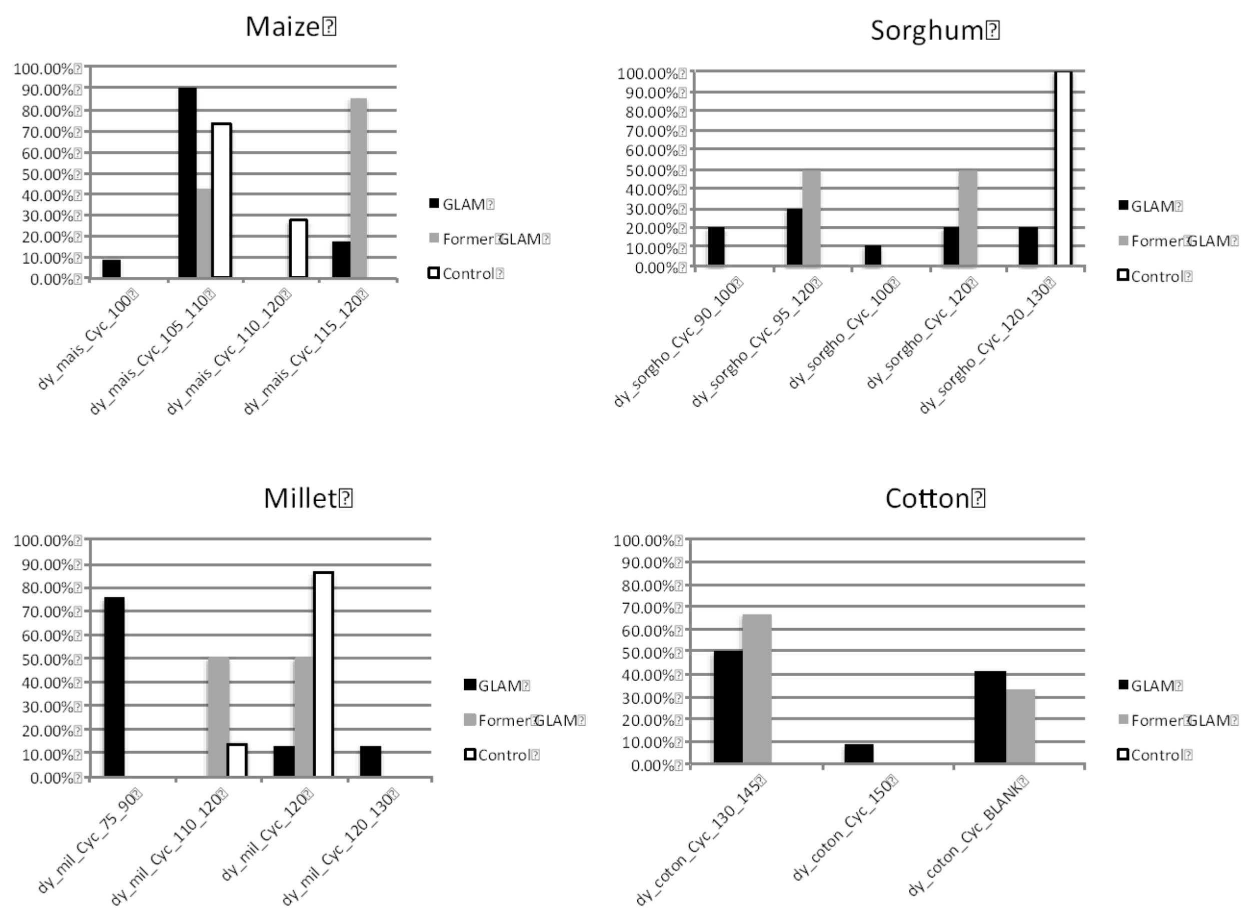



**Figure A23: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types.**

To control for the fact that only 1/3 of senior men in the GLAM village sample are using the advisories, Figure A24 considers their selections compared to all senior men in GLAM villages. This figure suggests there were differences in variety selection between all GLAM senior men and those that are using the advisories. Those using advisories were more focused on short-cycle cotton, similar to the selections of former GLAM farmers. Those using the advisories had a greater emphasis on longer-cycle maize, which attenuates the apparent selection difference between GLAM and other farmers. Again, this makes sense in the context of the advisories, which were advising 105-day cycles in early May when rainfall looked more or less normal. Those using advisories were also focused on short-cycle sorghum than the wider group of GLAM senior men, heightening the difference between these farmers and those in control villages. As with millet, sorghum is a crop for which advisories did not appear until late May, when rainfall had dropped below normal levels. Therefore, the pattern here likely reflects farmers holding off on planting sorghum until rainfall levels returned to normal, hitting the 10mm level in a single dekad. By the time this occurred, they were limited to shorter-cycle varieties by the length of the season. Perhaps most important, however, is the fact that those using the advisories often raised more than one variety of sorghum, suggesting that they were, at least for this crop, either using the advisories to manage their agricultural risk, or responding to different directed advice at different points in the season.

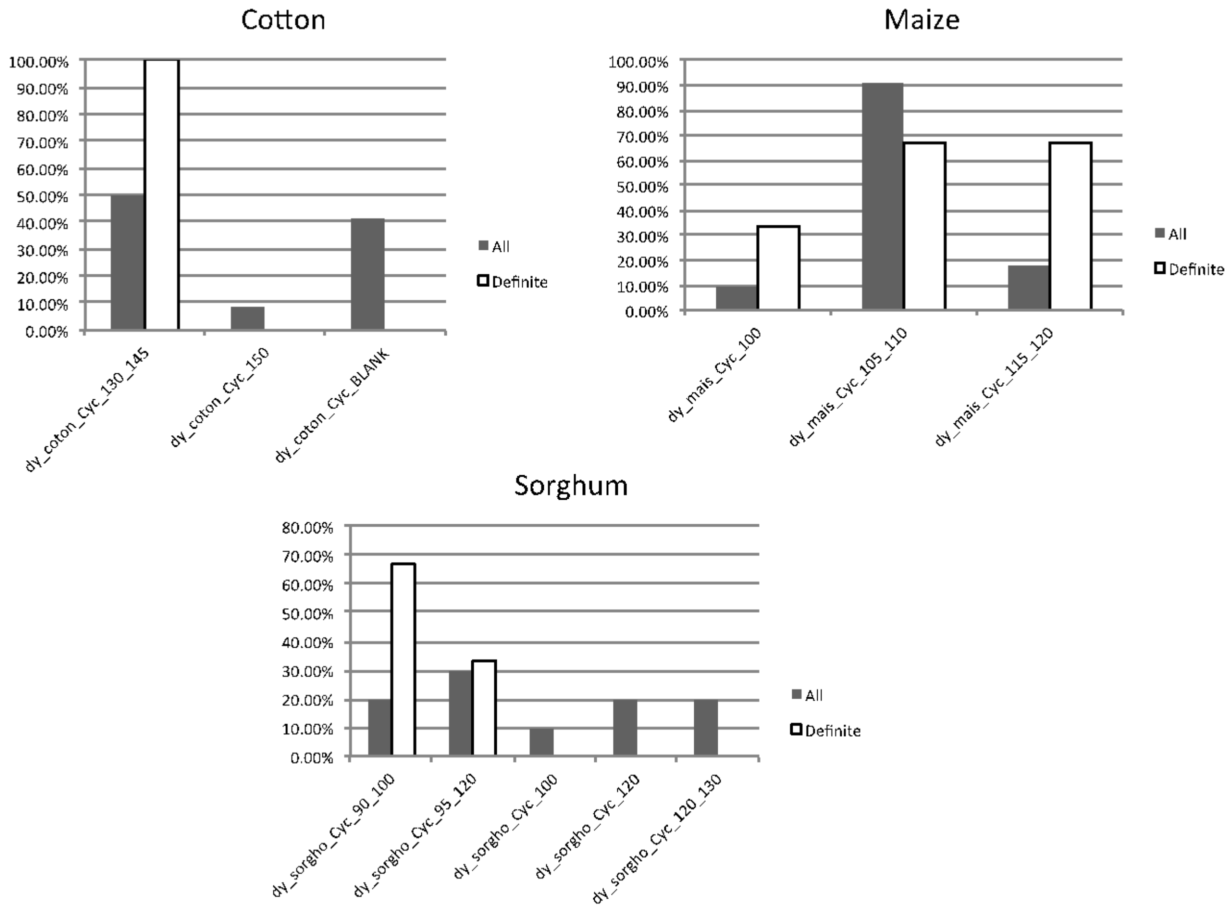



**Figure A24: Comparisons of variety selection among senior men in GLAM villages, comparing all such men and those that used the advisories and accurately reported the workings of the program.**

Figure A25, which illustrates the intended uses of these crops for senior men in GLAM, former GLAM, and control villages, provides further evidence that these groups employed different agricultural strategies. Those living in GLAM villages built their agricultural strategies around cotton cultivation, with the cultivation of maize as a principle subsistence staple and all other crops as staples for which any surplus might be marketed for extra income. This exposed the livelihoods of these men to the vagaries of CMDT payments, a challenge that might have been offset by their confidence in producing a marketable surplus beyond subsistence with many of their other crops. While the senior men in former GLAM villages raised cotton, they did so in fewer numbers than in GLAM villages, perhaps suggesting a shift away from this crop. If such a shift was underway, attributing it to either changing access to the agrometeorological advisories or the vagaries of CMDT payments is impossible with the data at hand. Sweet peas were the other major crop these men grew for market sale, though they also raised several other staples, all with the goal of meeting household subsistence and producing a marketable surplus. These men were still very market-oriented in their production, growing two crops for market sale alongside other staples, but had a different engagement with cash cropping than their GLAM counterparts. Senior men in control villages exhibited a very conservative agricultural strategy, raising only one crop for market purposes, likely an effort to add a single crop aimed at market sale into an otherwise subsistence-oriented farming strategy. These men appeared to have low confidence in their ability to produce marketable surpluses, even though they were growing more or less the same crops as those in GLAM and former GLAM villages.

**GLAM senior man**

| | |
|---|---|
| Cotton | Sell all |
| Maize | Eat all |
| Sorghum | Eat more than sell |
| Millet | Eat more than sell |
| Rice | Eat and sell equally |
| Peanut | Eat more than sell |
| Sweet potato | Eat and sell equally |
| Papaya | Sell all |
| Potato | Sell all |

**Former GLAM senior man**

| | |
|---|---|
| Maize | Eat more than sell |
| Millet | Sell more than eat |
| Sweet peas | Sell all |
| Cotton | Sell all |
| Sorghum | Sell more than eat |
| Rice | Eat more than sell |
| Peanut | Sell all |

**Control Senior Man**

| | |
|---|---|
| Maize | Eat all |
| Sorghum | Eat all |
| Millet | Eat all |
| Rice | Eat more than sell |
| Sweet potato | Sell all |
| Potato | Sell all |
| Cassava | Sell all |
| Cowpeas | Eat all |
| Fonio | Sell more than eat |
| Ginger | Sell all |
| Okra | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A25: Intended uses of all crops on two or more senior men's farms, in GLAM, former GLAM, and control villages, for cluster 2.**

In the case of senior men in cluster 2, there were three different agricultural strategies at work, one in each of the three village types. Senior men in GLAM villages clearly expected to raise the income they need from their agriculture (especially cotton) and livestock. Those in former GLAM villages appear to have disengaged from cotton production, and participated in livestock husbandry at much lower levels than seen in either GLAM or control villages. Therefore, these men were heavily reliant on their farms, and the cultivation of a marketable surplus of staple crops, to earn a living. Senior men in control villages were practicing the most defensive livelihoods, raising crops for subsistence, and apparently, focusing on the production of a single crop and perhaps the raising of livestock to earn a living. However, they are also focusing on long-cycle varieties, increasing the risk that they will suffer a failed harvest in a short season.

Junior Men

Only 22% (n=2) of the junior men in GLAM villages in cluster 2 reported using the advisories, and of these only one reported an adequate understanding of the program's function. This is a very small percentage of likely users, suggesting significant problems in the transmission of advisories and program function to potential users.

Junior men in GLAM villages grew an average of only 3.1 crops on their farms, significantly less than the 4.3 on those of former GLAM villages or the 5.1 in control villages (Figure A26). Maize was the most commonly raised crop among junior men of this cluster, raised by every farmer interviewed. A very similar percentage of men across all village types raised sorghum. Unlike among senior men, the rate of cultivation of sorghum did not map to the rate of livestock ownership. While junior men in GLAM villages had the highest rate of livestock ownership and sorghum cultivation, junior men in former GLAM villages reported the same rate of sorghum cultivation, though *none* reported owning livestock. Sorghum production appears slightly high for junior men in control villages relative to rates of livestock ownership, suggesting that sorghum is raised for more than the purposes of feeding household cattle by these men. There were also significant differences in crop selection across village types. Cotton was a major component of agriculture for junior men in GLAM villages, and was cultivated at much higher rates (78%) than in former GLAM villages (33%). Those in control villages did not raise cotton at all. Junior men in GLAM villages appeared to be shifting away from millet production when compared to junior men in the other two village types. Two thirds of junior men in former GLAM villages grew peanuts, which did not appear on junior men's farms in either GLAM or control villages.

**GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 3.1 |
| Maize | 100.00% |
| Cotton | 77.78% |
| Sorghum | 66.67% |
| Millet | 44.44% |
| Sweet potato | 11.11% |
| Rice | 11.11% |

**Former GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 4.3 |
| Maize | 100.00% |
| Millet | 100.00% |
| Sorghum | 66.67% |
| Rice | 66.67% |
| Peanut | 66.67% |
| Cotton | 33.33% |

**Control Junior Man**

| | |
|---|---|
| Avg # crops | 5.1 |
| Maize | 100.00% |
| Millet | 75.00% |
| Ginger | 75.00% |
| Potato | 62.50% |
| Sorghum | 50.00% |
| Rice | 50.00% |
| Sweet potato | 37.50% |
| Okra | 37.50% |
| Cassava | 25.00% |

**Figure A26: The crop selection preferences of junior men in cluster 2, with comparisons between GLAM, former GLAM, and control villages.**

Figure A27 demonstrates differences in crop selection among junior men in GLAM villages as we become more certain of their use of the advisories. Those using advisories farmed roughly one more crop than GLAM men in general and they farmed four of the GLAM crops grown in this cluster. While this suggests that the advisories did impact crop selections among this cohort in cluster 2, it is important to note that the sample here is very small (only one man was definitely using the advisories) and the reliability of this finding is low.

**GLAM Junior Man: All**

| | |
|---|---|
| Avg # crops | 3.1 |
| Maize | 100.00% |
| Cotton | 77.78% |
| Sorghum | 66.67% |
| Millet | 44.44% |
| Sweet potato | 11.11% |
| Rice | 11.11% |

**GLAM Junior Man: Probable**

| | |
|---|---|
| Avg # crops | 3.5 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Millet | 100.00% |
| Sorghum | 50.00% |

**GLAM Junior Man: Definite**

| | |
|---|---|
| Avg # crops | 4 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Millet | 100.00% |
| Sorghum | 100.00% |

**Figure A27: The crop selections of junior men in GLAM villages, by all, those claiming to use the advisories, and those that claim to use advisories and understand how the program works. Note: only one farmer demonstrated an adequate understanding of the program's function to suggest actual use of the advisories, and so this column may reflect individual idiosyncrasy as much as the influence of advisories on crop selection.**

Figure A28 illustrates the variety selection of junior men in cluster 2. Junior men in GLAM villages were generally focused on the cultivation of shorter-cycle varieties than their counterparts in former GLAM or control villages (though it is unclear what variety of cotton is being cultivated in the former GLAM villages, as the farmers did not provide a variety name during interviews). The selection of maize varieties seemed quite similar across villages at the community level, though in GLAM villages these selections were emphasized somewhat shorter cycles listed in the early-season advisories for this cluster, and likely reflect decisions made under what were, initially, normal rainfall conditions. Those in GLAM villages were focused on much shorter-cycle millet varieties than those in control villages. Junior men in GLAM and control villages have distributed their sorghum variety selection in similar manners, focusing on short cycle varieties and hedging with a few longer cycle varieties, while former GLAM villages have focused on varieties with a cycle right in the middle of the distribution. In the GLAM villages, both millet and sorghum selection are consistent with the use of advisories, as planting of these two crops would likely have been delayed by inadequate rainfall until the middle or later parts of June, forcing farmers into shorter cycle varieties. The relative de-emphasis of millet on GLAM farms might also suggest that farmers were avoiding this crop, or gave up on planting millet, perhaps because of advisories that by mid-June predicted a short, difficult season for the crop.

As with previous cohorts, any discussion of variety selection at the community level only holds if the community serves as a unit of climate risk management. There is insufficient evidence in the dataset to support or refute this idea. If the community is not a unit of climate risk management, nearly all junior men's production, across village types, was highly risky as it focused on the cultivation of a single variety. The exception was that of maize selection by junior men in former GLAM villages. Here, all farmers selected two varieties, hedging their farms against a slightly short season.

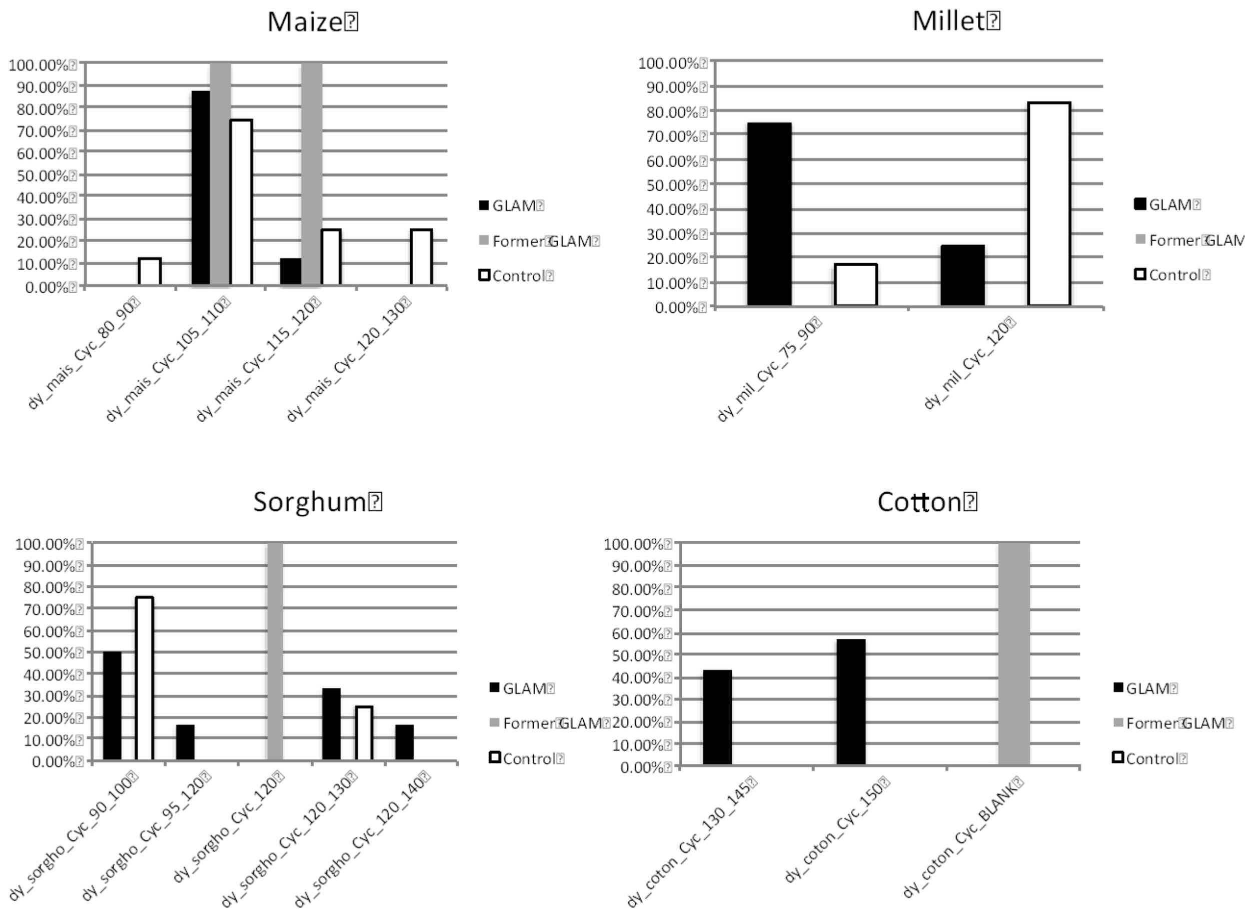



**Figure A28: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types.**

Figure A29 shows that those who claimed to use the advisories, and those definitely using the advisories, were focused on shorter-cycle varieties of cotton and sorghum than GLAM senior men in general. These were the only two crops for which there was a difference in variety selection. In the case of sorghum, this pattern makes the variety selection of those using the advisories resemble selections seen in control villages, but more clearly aligns with the advisories that would have delayed the planting of this crop, and eventually forced farmers into short-cycle varieties. The cotton variety selection of those using the advisories was focused on shorter-cycle varieties than among all junior men in GLAM villages, but it is difficult to assess the difference between these selections and those of former GLAM villages because those in former GLAM villages could not provide information on the cycle of the variety they were using.

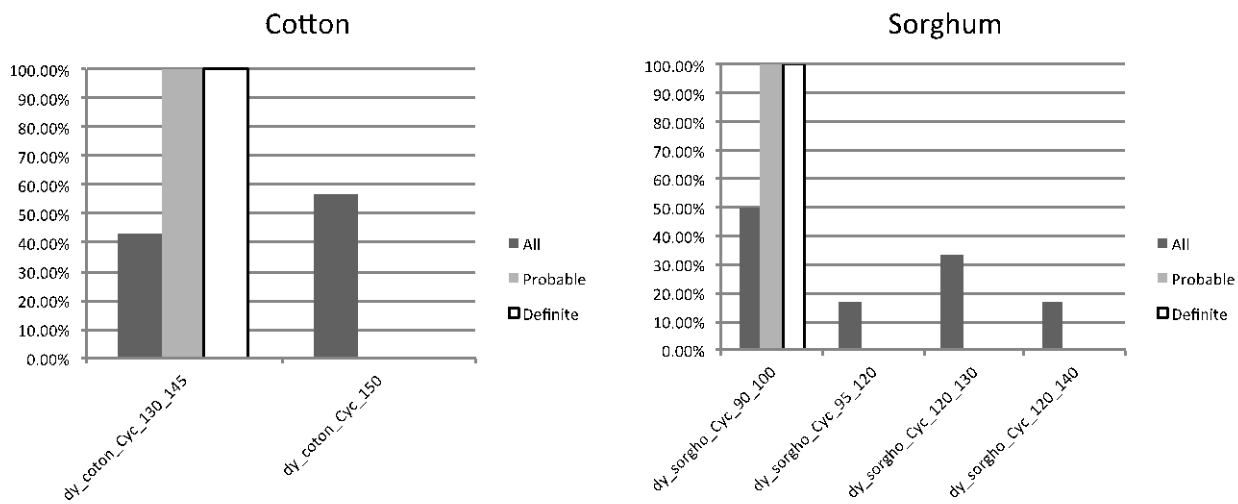



**Figure A29: Comparisons of variety selection among junior men in GLAM villages, comparing all such men, those that reported using the advisories, and those that accurately reported the workings of the program. Note: only one farmer demonstrated an adequate understanding of the program's function to suggest actual use of the advisories, and so this column may reflect individual idiosyncrasy as much as the influence of advisories on crop selection.**

Figure A30, which illustrates the intended uses of these crops for junior men in both GLAM and control villages, serves to translate these crop selections into an agricultural strategy. Most junior men in GLAM villages were focused on cotton production for income, with the other staple crops grown for subsistence first with any surplus sold for profit (though the infrequently grown sweet potato is also a market crop). They expected some surplus from all of these crops. Few junior men in former GLAM villages were growing cotton, but several appeared to be growing sorghum for sale, at least locally, to those who own animals and need the fodder. They were also growing peanuts as a cash crop. The uses of these two crops suggest that junior men in the former GLAM villages have shifted out of cotton production, but were still cash crop oriented, substituting sorghum and peanuts into the cash crop role. Junior men in control villages were much more conservative, growing both maize and millet for subsistence. However, they appear to then grow one or more crops with the intent of selling them, or at least selling any surplus (the only exception being sorghum). In short, their strategy is not dissimilar from that seen in GLAM and former GLAM villages, but it appears these farmers had less confidence in the production of a surplus of maize and millet. It is likely that this orientation was shaped by livelihoods in control villages. While access to agrometeorological advisories might contribute to this confidence, junior men in former GLAM villages also lacked access to these advisories, but appear to have greater confidence in their harvests than those in control villages. Nearly half of the junior men in control villages are engaged in gardening one or more crops. Their agricultural production is therefore more insulated from variable precipitation than that of their counterparts in GLAM villages, which may help to explain why these men did not list variable rainfall as a major problem. Further, this gardening took some of the market pressure from the production of maize and millet staples, enabling their use as subsistence crops.

**GLAM Junior Man**

| | |
|---|---|
| Maize | Eat more than sell |
| Cotton | Sell more than eat |
| Sorghum | Eat more than sell |
| Millet | Eat and sell equally |

**Former GLAM Junior Man**

| | |
|---|---|
| Maize | Eat more than sell |
| Millet | Eat and sell equally |
| Sorghum | Sell more than eat |
| Rice | Eat all |
| Peanut | Sell all |
| Cotton | Sell all |

**Control Junior Man**

| | |
|---|---|
| Maize | Eat all |
| Millet | Eat all |
| Ginger | Sell all |
| Potato | Sell more than eat |
| Sorghum | Eat all |
| Rice | Eat and sell equally |
| Sweet potato | Sell all |
| Okra | Sell all |
| Cassava | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A30: Intended uses of all crops on two or more junior men's farms, in GLAM and control villages, for cluster 2.**

In the case of junior men, it seems there was a divide between GLAM/former GLAM and control villages in terms of their approach to livelihoods and the management of the vulnerability context. Overall, junior men in GLAM villages focused their livelihoods on agricultural production for markets, livestock husbandry, and other nonfarm job opportunities, all of which brought in both food and significant cash. Junior men in former GLAM villages appear to be shifting out of cotton cultivation, but maintaining the market component of agricultural production under their previous strategy by shifting emphasis from cotton to sorghum and peanuts. These men did not own livestock, but engaged in trade (likely of sorghum and peanuts). As their trade was closely linked to their farms, this was not a very diversified livelihood. Junior men in control villages were principally subsistence agriculturalists who market their surpluses. Fewer of these men owned livestock when compared to their GLAM counterparts, but they did engage in some trade, likely related to the sale of their gardened crops. The participation of these men in gardening insulated them, to a limited extent, from the impacts of climate variability.

Senior Women

No senior woman in cluster 2 reported using the advisories, which suggests that any impact of the program on their agricultural practice stemmed from indirect influences, such as the crop and variety selections of their husbands and/or sons. The average senior women in GLAM villages grew 1.4 crops, slightly less than the 2.2 of senior women in former GLAM villages and the 1.7 of senior women in control villages. Figure A31 shows that all senior women in this cluster, whether in a GLAM, former GLAM, or control villages, emphasized rice production on their farms. Very few senior women living in GLAM villages planted crops besides rice on their farms, though most that were planted were targeted by GLAM advisories. Senior women in former GLAM villages usually planted one other crop alongside rice, and all three of the non-rice crops reported were targeted by agrometeorological advisories. Some senior women in control villages, like those in GLAM villages, planted a crop with rice. Most often, this crop was maize, which receives agrometeorological advisories, with ginger and sweet peas the other crops mentioned.

**GLAM Senior Woman**

| | |
|---|---|
| Avg # crops | 1.4 |
| Rice | 100.00% |
| Peanut | 20.00% |
| Maize | 10.00% |
| Sorghum | 10.00% |

**Former GLAM senior Woman**

| | |
|---|---|
| Avg # crops | 2.2 |
| Rice | 80.00% |
| Maize | 40.00% |
| Millet | 40.00% |
| Peanut | 20.00% |
| Sorghum | 20.00% |
| Sweet peas | 20.00% |

**Control Senior Woman**

| | |
|---|---|
| Avg # crops | 1.7 |
| Rice | 100.00% |
| Maize | 44.44% |
| Ginger | 11.11% |
| Sweet peas | 11.11% |

**Figure A31: The crop selection preferences of senior women in cluster 2, with comparisons between GLAM and control villages.**

Figure A32 illustrates the variety selection of senior women in this cluster. There is little to distinguish these selections across village types, though at the community level women in GLAM villages seemed to focus on a single cycle of maize, while those in former GLAM and control villages distributed their selections across a range of cycles. The few senior women in GLAM villages growing peanuts selected a much longer cycle variety than their former GLAM counterparts.

Interesting here is that the few women growing these crops in former GLAM villages often planted more than one variety at time. This is a more resilient individual strategy for managing the risks associated with climate variability in rain-fed agriculture than seen in other villages, where each farmer planted a single variety. At the same time, relatively few of these women planted these crops in any of the villages in this cluster, and therefore their risks were probably more related to rice production, for which there is no advisory.

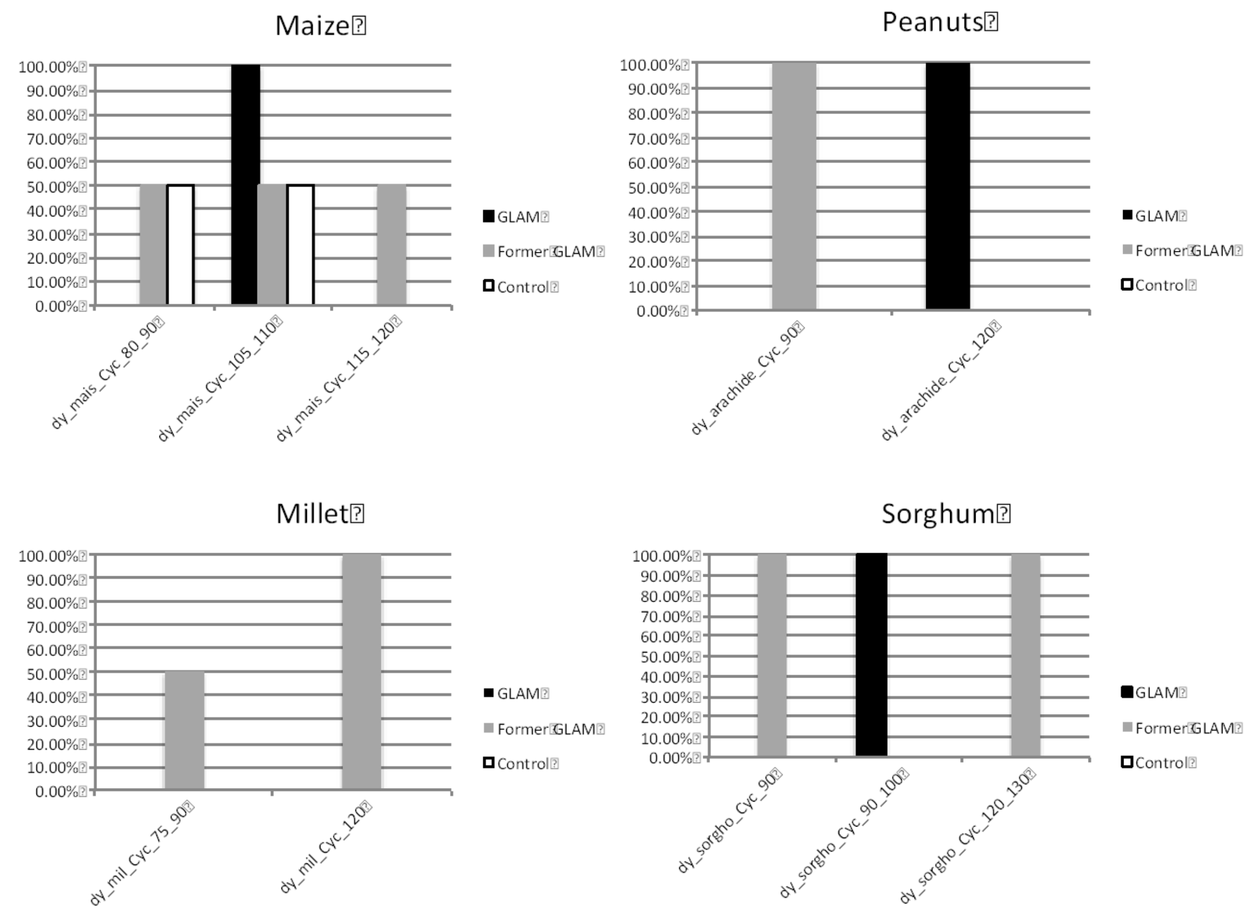



**Figure A32: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types.**

Figure A33, which illustrates the intended uses of these crops for senior women in both GLAM and control villages, does little to differentiate the agricultural strategies of these women across the different villages in this cluster. In all cases, women planted their crops with the principal goal of subsistence, and sought to market any surplus. The exception was with maize in control villages, which appears to have been grown solely for subsistence production. It is difficult to generalize from a single crop, and therefore it is unclear if this emphasis represents a meaningful shift toward subsistence on the part of women in control villages versus those in GLAM and former GLAM villages.

| GLAM Senior Woman | |
|---|---|
| Rice | Eat more than sell |
| Peanuts | Eat more than sell |

| Former GLAM senior Woman | |
|---|---|
| Rice | Eat more than sell |
| Maize | Eat more than sell |
| Millet | Eat more than sell |

| Control Senior Woman | |
|---|---|
| Rice | Eat more than sell |
| Maize | Eat all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A33: Intended uses of all crops on two or more senior women's farms, in GLAM and control villages, for cluster 2.**

Overall, senior women in this cluster appear to play the role of subsistence producer first, with any marketing of agricultural production the product of surpluses on that subsistence production. However, agriculture was not the only livelihoods activity these women undertook. In GLAM villages, senior women engaged in trading, owned livestock, and cut firewood. In former GLAM villages, senior women were more heavily engaged in trading, owned livestock at lesser rates than their GLAM counterparts, and did not cut wood at all. In control villages, senior women did not own any livestock, and only about 20% engaged in trading. However, many of these women cut or gathered firewood, and they took up other small, irregular jobs as they become available. While these were three somewhat different suites of livelihoods activities, they all resulted in diversified incomes that built on a subsistence agricultural foundation. It is clear that in the assessment sample in this cluster, the senior women in GLAM villages were wealthier than former GLAM villages, who in turn were more wealthy than those in control villages. However, it is not clear if this was an effect of program participation, or was a preexisting situation that shaped the selection of GLAM villages during program scale-up.

Junior Women

One junior woman in this cluster claimed to be using the advisories. She did not, however, accurately report on the functioning of the program or the advisories, suggesting that she is not using the advisories appropriately, if at all. Further, as only a single woman claimed to use the advisories, it is impossible to distinguish between her individual choices with regard to crop selection and the influence of the program with the data at hand. Therefore, we cannot say if there is any real impact of the advisories on junior women's peanut production in this cluster (peanuts are the only GLAM crop grown by junior women in cluster 2).

In cluster two, junior women in GLAM villages grew an average of 1.9 crops, slightly more than the 1.2 reported in former GLAM villages or the 1.8 in control villages. Rice is a very important crop to junior women, regardless of residence (Figure A34). However, where rice is clearly the most commonly cultivated crop in GLAM and control villages, those in former GLAM villages cultivated both rice and peanuts at the same rate, with maize and peas as the remaining crops. Junior women in this village were therefore choosing between rice (for which there is no advisory) and peanuts (for which there is an advisory). One of the women in a GLAM village was gardening, which provided her production with somewhat greater resilience in the face of uncertain precipitation than those solely focused on rain-fed agriculture, but it is not clear that her gardening was representative of a larger trend in the GLAM villages. In control villages, junior women did not cultivate any crops for which there was an advisory, so the program had no direct impact on their agricultural practice.

**GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 1.9 |
| Rice | 100.00% |
| Peanuts | 30.00% |
| Okra | 20.00% |
| Eggplant | 10.00% |
| Cabbage | 10.00% |
| Chili pepper | 10.00% |
| Tomato | 10.00% |

**Former GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 1.2 |
| Rice | 40.00% |
| Peanuts | 40.00% |
| Maize | 20.00% |
| Sugar peas | 20.00% |

**Control Junior Woman**

| | |
|---|---|
| Avg # crops | 1.8 |
| Rice | 100.00% |
| Okra | 40.00% |
| Ginger | 40.00% |

**Figure A34: The crop selection preferences of junior women in cluster 2, with comparisons between GLAM and control villages.**

Figure A35 represents junior women's variety selections associated with peanuts, the only crop for which there were different selections recorded in this cluster. Those in GLAM villages were completely focused on long-cycle varieties, while those in former GLAM villages distributed their selections across short and long cycles. Each individual woman, however, was planting only a single variety, thus all were exposed to a seasonal variability.

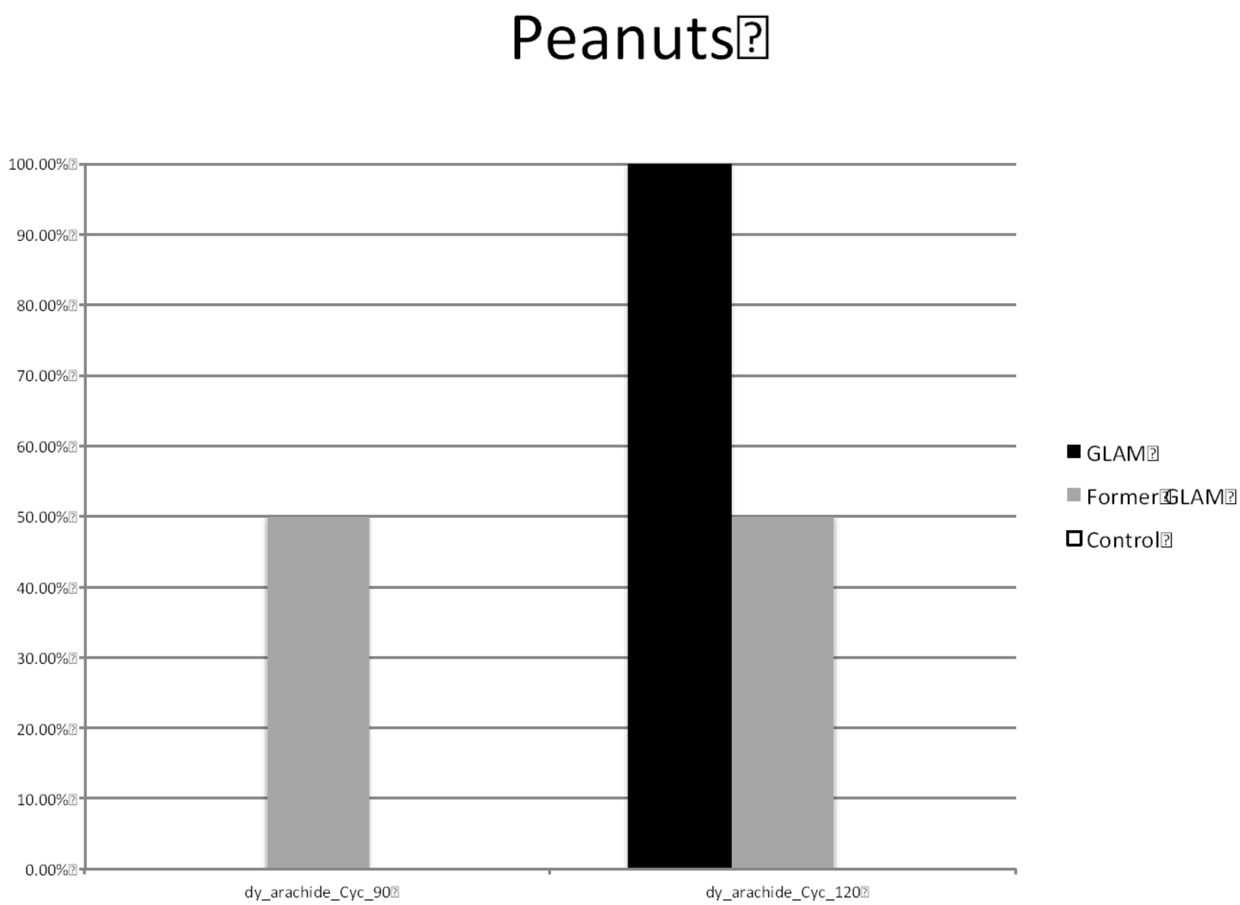



**Figure A35: Charts representing variety selection for the four advisory-informed crops for which there were significant differences in variety selection across the village types.**

Figure A36, which illustrates the intended uses for crops on the farms of junior women in this cluster, shows a very similar strategy behind agricultural production across GLAM, former GLAM, and control settings. Women in GLAM villages clearly planted their rice with the intent of selling at least some of it regardless of harvest outcomes, while women in former GLAM and control villages were aiming for a marketable surplus. The next most common crop on women's farms in GLAM villages, peanuts, was also grown with the goal of sale and consumption, this time both by junior women in GLAM and in former GLAM villages. Peanuts did not appear on the farms of junior women in control villages in cluster 2. This absence may have been related to the lack of agrometeorological advisories in the se villages, as peanuts are very sensitive to pauses in the rainy season and therefore their planting can be challenging without forecast information. Okra, which appears on the farms of junior women in both GLAM and control villages, was grown for household consumption. Interestingly, ginger (grown by 40% of junior women in control villages) appears to be a cash crop that has no counterpart in GLAM and former GLAM villages.

**GLAM Junior Woman**

| | |
|---|---|
| Rice | Eat and sell equally |
| Peanuts | Eat and sell equally |
| Okra | Eat all |

**Former GLAM Junior Woman**

| | |
|---|---|
| Rice | Eat more than sell |
| Peanuts | Sell more than eat |

**Control Junior Woman**

| | |
|---|---|
| Rice | Eat more than sell |
| Okra | Eat all |
| Ginger | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A36: Intended uses of all crops on two or more junior women's farms, in GLAM and control villages, for cluster 2.**

The broad similarities in junior women's agricultural strategy across GLAM, former GLAM, and control settings in cluster 2 were paralleled by broadly similar livelihoods. Junior women in GLAM villages were heavily engaged with trading. A few owned livestock and cut/gathered firewood. In former GLAM villages, junior women were similarly engaged in trading, but did not own livestock or cut/gather wood. Instead, they worked irregular jobs. Junior women in control villages most heavily focused on gathering and picking fruit from trees in the area. About half of these women engaged in trade, and some women participated in livestock husbandry, firewood cutting and collection, and other odd jobs. As fruit picking is sometimes associated with the poorest households in this livelihoods zone (Dixon & Holt, 2010, p.110), this may be an indication that the sample of junior women in the control village were disproportionately poor. In any case, these livelihoods activities were clearly ancillary to the main activity of agriculture, and do not serve to differentiate the livelihoods of junior women in GLAM, former GLAM, and control settings in cluster 2.

### 6.3.4. CLUSTER 2 SUMMARY

Possible Program Impacts

In cluster 2, agriculture was the center of livelihoods, and farmers raised all five crops targeted by the agrometeorological advisory program. Therefore the potential impact of the program on productivity and income was quite high in this cluster. However, only one third of senior men, and just over 20% of junior men, reported using the advisories. This low figure is somewhat inflated, as only half of the junior men who reported using the advisories were able to accurately explain how the agrometeorological program worked. No women accurately reported on the workings of the program, and therefore it is unlikely that any of the women sampled in this cluster are directly using the advisories. It is not surprising that women are not using the advisories. In cluster 2, few women grew GLAM crops. The principal crop of women, rice, was not part of the advisory program. As a result, this program likely had little, if any, direct impact on their agricultural decisions or outcomes. It is also worth noting that women in this cluster tended to grow different crops than men, limiting the influence of husbands and sons over the production of their wives and mothers.

The agricultural production of men living in GLAM villages was much more market oriented than that in other villages, with declining market engagement across former GLAM and control settings. This is most clearly manifest in the focus on cotton production in GLAM villages. It is not clear from the data at hand if this is a product of engagement with the program, or a reflection of the preexisting conditions that shaped selection for participation in the program in the first place.

There was little evidence of advisory influence on the crop selections of men and women, though among men there appeared to be a somewhat greater focus on the cultivation of GLAM crops where advisories were available. The de-emphasis of millet by junior men who were using the advisories is consistent with a delayed season that might have challenged their ability to raise a productive crop, but this explanation is not definitive with the evidence at hand. The differences in crop selection within GLAM villages, between those using the advisories and those who are not, are inconclusive. Sorghum variety selection appears to run to the shorter cycles in GLAM villages. Among junior men, those in GLAM villages appeared to be planting shorter cycle varieties for nearly all crops, but the number of men actually using the advisories is very small and the relationship between the advisories and this trend is not clear. There were differences in variety selection within GLAM villages between those using the advisories and those that were not, but these differences draw upon small samples that are difficult to generalize rigorously. All of this said, the patterns of variety selection for maize, peanuts, millet, and sorghum for the men using the advisories are consistent with the use of the advisories, and explain why some crops were long cycle, and others much shorter cycle.

Finally, in this cluster there is a significant problem with variety selection across all villages. Farmers tend to focus on planting a single variety, with any diversity in selection coming at the level of the community. This does not appear to be a function of seed availability, as it was not listed as a major concern by any of the groups in any village. At the very least, in GLAM villages this suggests that farmers have not been adequately trained in the use of the advisories to inform their variety selection, as these advisories may be relying on the misreading of probabilistic forecasts as accurate seasonal predictions, instilling false confidence in particular cycles that could result in disaster when forecasts are wrong.

To summarize, specific instances of difference between GLAM and control settings that might be linked to program impact:

1) Crop selection:
    a. Both senior men and junior men in GLAM villages plant cotton, while those in former GLAM and control villages do not. As there are many factors that dictate the viability of cotton in a given year, including the function of CMDT and trends on regional and global markets, it is not clear if climate information is a significant contributor to the decision to plant cotton in GLAM villages. There is some circumstantial evidence to support this conclusion:
        i. Junior men in former GLAM villages appear to have maintained the same general structure to agricultural strategy as those in GLAM villages, only now are substituting other crops (sorghum and peanuts) in place of cotton for their "cash

crop." This may suggest that the shift away from cotton was indeed related to the loss of agrometeorological advisories.

ii. Senior men in former GLAM villages appear to have shifted how they use certain crops (millet and maize) from subsistence to market sale, perhaps filling the gap created by the loss of cotton.

iii. In both cases, the "new" cash crops are those informed by advisories, and while these men in former GLAM villages may not get the advisories any more, they may have lingering confidence in these crops based on their previous experiences.

iv. It is therefore possible that information in the advisories contributed to this pattern of crop selection, but definitive establishment of this relationship will require further research..

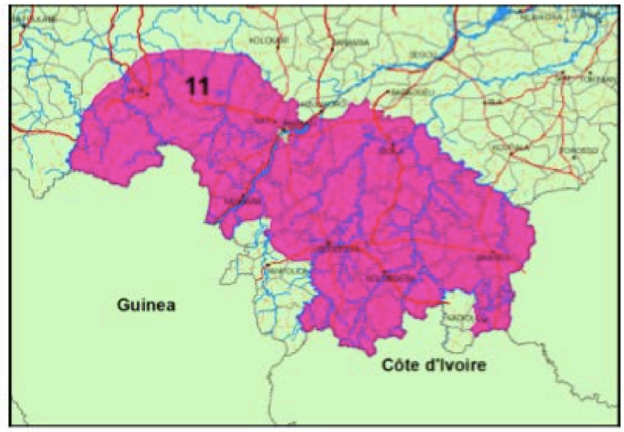
2) Variety selection:
   a. Those who are clearly using the advisories displayed patterns of variety selection consistent with the advisories as applied to their particular precipitation situations.
      i. In many cases, these selections are different than those in non-GLAM villages, and even different from those in GLAM villages who did not display a clear understanding of the agrometeorological program.
      ii. It appears that those who understand the program are using the advisories to inform their variety selections.
3) Agricultural strategy:
   a. The junior and senior men with experience of the agrometeorological program, whether current or past, appear to be more market oriented with their agricultural production. In general, they appear to expect marketable surpluses from their staple crops, while their control counterparts do not.
   b. It appears this overall difference in strategy is linked to the use of advisories.

Provisional decision-making model to inform future design

In cluster 2, both men and women structure their livelihoods somewhat conservatively, to both meet the subsistence needs of the household directly (via staple crop production) and through cash income earned through other livelihoods activities and the sale of surplus agricultural production. In general, men are somewhat more responsible for cash incomes, and take on more market-oriented agricultural strategies, than do women of the same seniority cohort. There are few differences in strategy between junior and senior men. The differences between men's strategies across GLAM, former GLAM, and control villages are not the product of different interpretations of gender roles and responsibilities, but the opportunities available to men in these different settings. While the growth of cotton, a cash crop and a potential core source of income, is limited to men in GLAM villages, men in former GLAM villages are clearly trying to generate cash income from their agricultural production by substituting other crops, such as millet or sorghum, in lieu of cotton. Those in control villages incorporate a few crops expressly intended for market sale. The principal difference in strategy between the men in these three village types relates to their confidence in their harvests, and perhaps the information and connections that would facilitate cotton cultivation. It may be that access to agrometeorological advisories improves the confidence of the farmers in GLAM villages (and the historical experience of the advisories for those living in former GLAM villages plays a similar role). In short, both junior and senior men seem to desire market engagement from their agricultural production, and will take advantage of opportunities to generate a marketable surplus of any crop, and any opportunity to take on a reliable cash crop. The only seeming change in roles across these villages is the relatively large percentage of men in the control village that were gardening. In other clusters, gardening is generally seen as a women's activity, though at times more senior men take up gardening as their mobility declines. Nobody in this cluster except these men reported gardening, suggesting that this activity might not carry the same gendered connotations as it does in other clusters. If not, the adoption of gardening by junior men in control villages may be an effort to manage uncertain precipitation by shifting some production into irrigated agriculture.

Women in these villages grow their crops with both subsistence and sale in mind. This was true across all village types and seniority. They are clearly hedging their production against bad rainfall and perhaps against uncertain markets, as they expect a marketable surplus (and therefore hope to produce at least subsistence in a bad year), but can also eat any crop they grow should markets turn against them. Women have unique responsibilities in the livelihoods of this cluster, as they control all picking and gathering of fruits from trees on their family land (and, at times, on the land of others in the village), wood cutting and firewood collection, and they dominate trading. Picking/gathering and firewood collection are principally subsistence activities, reinforcing women's place in the role of subsistence producer, while their engagement with trade appears closely linked to their own or their household's agricultural production. In short, their trading is tied to the production of a marketable surplus, which women generate after meeting the subsistence needs of the household. This does not mean that women cannot engage in exclusively market production with their agriculture, as women in control villages raised ginger for sale. However, this was one crop in a set of crops, and one activity in a set of activities, that were on the whole focused on the generation of subsistence. Climate services present an intriguing opportunity for women, for if such services allowed for the production of marketable surpluses, women might be able to generate incomes not only for their households, but also the capital necessary to engage in other livelihoods activities.

## 6.4. CLUSTER 3: ML11 "SOUTH MAIZE, COTTON, AND FRUITS"


**Location of the livelihoods zone to which Cluster 3 villages belong. Source: Dixon and Holt, 2010, p.101.**

### 6.4.1. VULNERABILITY CONTEXT

The six villages of cluster 3 are located in the Kayes and Koulikoro regions of Mali, covering a range roughly 150 km East-Southeast of Bamako to 150 km West-Northwest of Bamako. This highly agriculturally productive part of the country receives between 1000-1300 mm of rain annually. Rain falls principally from May through October, with the heaviest amounts arriving from July through September (Dixon & Holt, 2010, p. 101). The villages in this cluster are all located at least 120 km from Bamako, and therefore do not fall into the peri-urban zone around the capital that now focuses a great deal of production on vegetable crops for the urban market.

Farmers in this cluster experience a hungry season that starts in June and runs through the August harvests. This season is longer and more pronounced for poor households. Dixon and Holt (2010, p.103) note that these poorer households often must work for wealthier households to earn money for food. This is of critical importance to this assessment, as such work means that these households will often plant later and devote less time to their own farms as they focus on farm labor for others. In short, poorer households will have less capacity to act on climate information regardless if they have access to it, as they will often have less control over the timing of planting and weeding than wealthier households. Income shortages are, for the wealthy, mitigated by the consumption and sale of milk from livestock. The poor, who own few or no cattle, have limited options, though income shortages can be mitigated by women gathering shea nuts during the hungry season (Dixon & Holt, 2010: p.102).

Dixon and Holt (2010, p.102) note that in this zone maize, cotton, and various gardened fruits and vegetables are sold via local markets, which then serve domestic urban markets in Mali, especially Bamako. Livestock are often sold in Cote d'Ivoire and Senegal, though poultry tend to be sold for domestic consumption. This creates an interesting pattern of market vulnerability in this cluster. While all agricultural production, whether from wealthy or poor farms, goes to the same markets, the livestock component of the livelihoods of the wealthiest households leaves them the most exposed to market shocks related to border closings and the political situation in neighboring countries.

According to Dixon and Holt (2010, p.107), residents of the zone to which this cluster of villages belongs list variable and unpredictable precipitation, access to agricultural inputs, pests (including birds, cotton diseases, and other pests that eat plants or seeds), animal illnesses, inadequate pasturage and water for livestock, and access to appropriate seeds as principal challenges. Some residents also noted that the closure of the border with Cote d'Ivoire caused hardship in their livelihoods. Poor farmers reported the use of short-cycle seeds to address rainfall challenges, while wealthier households had the option of selling off livestock to meet their needs.

The focus groups conducted in this cluster for the assessment program disaggregated perceived challenges and vulnerabilities by gender and seniority (Figure A37). The varying perceptions of precipitation are of interest here. In GLAM and former GLAM villages, variable precipitation appeared as the top challenge (except among senior men in GLAM villages, who still saw it as in the top half of issues they addressed in their livelihoods). In control villages, however, only junior men and senior women mentioned irregular rainfall as a top challenge, while senior men and junior women did not mention it at all. Only junior men and women mentioned access to inputs as a challenge, a problem seen as a fairly high priority for members of these cohorts across village types. All cohorts in this cluster mentioned access to adequate seeds as a relatively minor challenge. Pests were major challenges for everyone living in GLAM villages except junior men (who did not mention them). The only mentions of pests outside of GLAM villages came from senior women in former GLAM villages and junior men in control villages. It is not clear from the data at hand whether this means that the GLAM villages in this sample were somehow hit harder by pests than the others, or if this is a difference in perception related to the relative manageability of other stressors. Access to adequate land arose as a challenge across all cohorts in GLAM villages, but was of greatest importance to senior men (who owned the most livestock), whereas women (who owned little to no livestock) generally rated it as a minor issue. Similarly, concerns for water availability were highest among senior men, who had to water their livestock, with junior women (who both gardened and owned some livestock) the group next most concerned with this issue. Perceptions of the vulnerability context therefore varied by gender, seniority, and engagement with the agrometeorological program. This variation is reflected in the livelihoods strategies and agricultural practices of those living in this cluster.

| Junior Men | GLAM average | Former GLAM | Control average |
|---|---|---|---|
| Lack of farming equipment | 1.7 | 1.5 | 3.0 |
| Irregular/inadequate rainfall | 2.0 | 1.0 | 1.0 |
| Lack of inputs | 2.0 | 3.0 | 2.0 |
| Land cover and soil degradation | 3.0 | 2.0 | |
| Low access to land | 4.0 | 6.0 | |
| Lack of animal fodder | 4.5 | 5.0 | |
| Animal health/vets | 5.0 | | |
| Market problems | 6.0 | 3.0 | |
| Livestock management | 6.0 | | |
| Transportation infrastructure | | 4.0 | |
| Water availability | | 4.5 | 6.0 |
| Lack of good seeds | | | 5.0 |
| Pests | | | 4.0 |

| Senior Men | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Land cover and soil degradation | 1.5 | 2.0 | |
| Lack of farming equipment | 2.0 | 3.0 | |
| Low access to land | 2.0 | 5.0 | 1.0 |
| Water availability | 2.0 | 6.0 | |
| Animal health/vets | 2.0 | | |
| Livestock management | 3.0 | | |
| Pests | 3.0 | | |
| Irregular/inadequate rainfall | 4.0 | 2.0 | |
| Lack of good seeds | 4.0 | 4.0 | |
| Market problems | 5.0 | 1.0 | |
| Cattle Stealing | | | 3.0 |
| Fire | | | 2.0 |

| Junior Women | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1.0 | 1.0 | |
| Lack of farming equipment | 1.5 | 1.5 | 2.0 |
| Pests | 2.0 | | |
| Water availability | 2.5 | 2.0 | |
| Lack of inputs | 3.0 | 3.0 | 1.0 |
| Animal health/vets | 3.0 | 5.0 | 5.0 |
| Low access to land | 3.0 | | |
| Lack of animal fodder | 5.0 | | |
| Lack of good seeds | | 4.0 | 3.0 |
| Transportation infrastructure | | 4.0 | |
| Food Shortage | | | 4.0 |

| Senior Women | GLAM average | Former GLAM average | Control average |
|---|---|---|---|
| Irregular/inadequate rainfall | 2.0 | 1.5 | 1.0 |
| Lack of farming equipment | 2.0 | 2.0 | 3.0 |
| Pests | 2.0 | 4.0 | |
| Animal health/vets | 2.0 | 4.5 | 5.0 |
| Lack of inputs | 3.0 | 5.0 | 4.0 |
| Livestock management | 3.0 | | |
| Lack of good seeds | 4.0 | 2.0 | 2.0 |
| Low access to land | 4.0 | | 6.0 |
| Food Shortage | 5.0 | | |
| Land cover and soil degradation | | 4.0 | |
| Lack of animal fodder | | 5.0 | |

**Figure A37: Principal livelihoods challenges, as reported by focus groups in cluster 3.**

### 6.4.2. LIVELIHOODS IN CLUSTER 3

In cluster 3, agriculture was the foundation of livelihoods with nearly every respondent (n=119) listing agriculture as one of their livelihoods activities (Figure A38). Livestock husbandry was also tremendously important in this cluster. Every cohort, across village types, contained at least a few people raising livestock of some sort, with the lowest rates of ownership among junior and senior women in GLAM villages. Large percentages of the women, both junior and senior, in control villages owned cattle, sheep, and goats. Junior and senior women in former GLAM villages tended to own more goats than any other animal. Gardening was dominated by women in this cluster, though 1/3 of senior men in GLAM and former GLAM villages also gardened. Participation in hand-irrigated gardening might explain why these men were relatively less concerned about irregular rainfall when compared to senior men in control villages, and to the population of this cluster in general. Women also dominated trading and business, though 40% of junior men in control villages participated in trade. Gathering and picking fruits and wild plants was an exclusively women's activity, with the highest rates of participation taking place in control villages. All other livelihoods activities were conducted by only a few individuals throughout the cluster, and are therefore difficult to interpret in relation to gender- or seniority-related roles.

| | GLAM senior man (N=15) | Former GLAM senior man (N=10) | Control Senior Man (N=5) | GLAM Senior Woman (N=15) | Former GLAM senior Woman (N=9) | Control Senior Woman (N=5) | GLAM Junior Man (N=15) | Former GLAM Junior Man (N=10) | Control Junior Man (N=5) | GLAM Junior Woman (N=15) | Former GLAM Junior Woman (N=10) | Control Junior Woman (N=5) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 100.00% | 100.00% | 100.00% | 93.33% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| Livestock | 100.00% | 80.00% | 80.00% | 53.33% | 100.00% | 100.00% | 73.33% | 90.00% | 80.00% | 26.67% | 100.00% | 100.00% |
| Gardening | 20.00% | 20.00% | 0.00% | 60.00% | 66.67% | 40.00% | 13.33% | 0.00% | 40.00% | 66.67% | 40.00% | 100.00% |
| Business | 0.00% | 10.00% | 0.00% | 66.67% | 0.00% | 60.00% | 26.67% | 20.00% | 0.00% | 86.67% | 80.00% | 100.00% |
| Gathering/ picking | 0.00% | 0.00% | 0.00% | 53.33% | 66.67% | 80.00% | 0.00% | 0.00% | 0.00% | 66.67% | 50.00% | 100.00% |
| Other | 6.67% | 3.00% | 0.00% | 26.67% | 0.00% | 40.00% | 13.33% | 30.00% | 20.00% | 0.00% | 0.00% | 0.00% |
| Handicrafts | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 20.00% | 6.67% | 10.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Logging | 0.00% | 0.00% | 0.00% | 13.33% | 11.11% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Agroforestry | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 13.33% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Figure A38: Livelihoods activities in cluster 3.**

### 6.4.3. AGRICULTURE IN CLUSTER 3

Farmers in cluster 3 raised 19 crops (Table A3). Of these, two (sweet potatoes and soy) were exclusively men's crops, while three more (sorghum, cotton, and millet) were dominated by men. Cotton, millet, and sorghum were crops farmed in this zone for which there are agrometeorological advisories. Twelve were women's crops, but none was a crop targeted by the agrometeorological program. Therefore, there was

| | GLAM senior man | Former GLAM senior man | Control Senior Man | GLAM Senior Woman | Former GLAM senior Woman | Control Senior Woman | GLAM Junior Man | Former GLAM Junior Man | Control Junior Man | GLAM Junior Woman | Former GLAM Junior Woman | Control Junior Woman |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg # crops | 513.33% | 340.00% | 500.00% | 553.33% | 433.33% | 520.00% | 542.86% | 470.00% | 580.00% | 666.67% | 610.00% | 1040.00% |
| Peanut | 66.67% | 50.00% | 40.00% | 93.33% | 88.89% | 100.00% | 71.43% | 70.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| Eggplant | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 26.67% | 30.00% | 100.00% |
| Banana | 0.00% | 0.00% | 0.00% | 0.00% | 11.11% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Baobob | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Cabbage | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 6.67% | 20.00% | 0.00% |
| Cotton | 100.00% | 80.00% | 60.00% | 0.00% | 11.11% | 0.00% | 100.00% | 70.00% | 80.00% | 0.00% | 10.00% | 0.00% |
| Fonio | 13.33% | 20.00% | 0.00% | 26.67% | 22.22% | 0.00% | 14.29% | 10.00% | 0.00% | 26.67% | 50.00% | 0.00% |
| Okra | 0.00% | 0.00% | 0.00% | 66.67% | 55.56% | 60.00% | 0.00% | 0.00% | 0.00% | 93.33% | 80.00% | 100.00% |
| Lettuce | 0.00% | 0.00% | 0.00% | 46.67% | 11.11% | 20.00% | 0.00% | 0.00% | 0.00% | 66.67% | 20.00% | 40.00% |
| Maize | 86.67% | 60.00% | 100.00% | 26.67% | 22.22% | 80.00% | 85.71% | 70.00% | 100.00% | 0.00% | 40.00% | 0.00% |
| Cassava | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 40.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 80.00% |
| Mint | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Millet | 33.33% | 20.00% | 20.00% | 0.00% | 33.33% | 0.00% | 71.43% | 50.00% | 20.00% | 6.67% | 0.00% | 0.00% |
| Cowpeas | 60.00% | 10.00% | 40.00% | 60.00% | 44.44% | 20.00% | 71.43% | 70.00% | 40.00% | 40.00% | 30.00% | 100.00% |
| Onion | 0.00% | 0.00% | 0.00% | 73.33% | 22.22% | 0.00% | 0.00% | 0.00% | 0.00% | 66.67% | 70.00% | 100.00% |
| Hibiscus | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 33.33% | 0.00% | 80.00% |
| Papaya | 0.00% | 0.00% | 0.00% | 0.00% | 11.11% | 20.00% | 0.00% | 0.00% | 20.00% | 0.00% | 10.00% | 40.00% |
| Sweet potato | 13.33% | 0.00% | 60.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 40.00% | 0.00% | 0.00% | 0.00% |
| Chili pepper | 0.00% | 0.00% | 0.00% | 13.33% | 0.00% | 40.00% | 0.00% | 0.00% | 0.00% | 46.67% | 20.00% | 100.00% |
| Bell Pepper | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 13.33% | 10.00% | 0.00% |
| Rice | 20.00% | 0.00% | 0.00% | 93.33% | 66.67% | 80.00% | 21.43% | 0.00% | 20.00% | 66.67% | 80.00% | 20.00% |
| Sesame | 20.00% | 0.00% | 80.00% | 0.00% | 0.00% | 20.00% | 7.14% | 30.00% | 40.00% | 0.00% | 0.00% | 0.00% |
| Soy | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% | 0.00% | 0.00% |
| Sorghum | 100.00% | 100.00% | 100.00% | 0.00% | 22.22% | 20.00% | 100.00% | 90.00% | 100.00% | 13.33% | 10.00% | 0.00% |
| Tomato | 0.00% | 0.00% | 0.00% | 20.00% | 11.11% | 0.00% | 0.00% | 0.00% | 0.00% | 26.67% | 20.00% | 80.00% |
| Bambara nuts | 0.00% | 0.00% | 0.00% | 6.67% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 33.33% | 10.00% | 100.00% |

| | |
|---|---|
| Onion | Women's crop |
| Rice | Men's crop |
| Sorghum | Crop targeted by the agromet program |

likely some gender differentiation of benefits from this program as men farm more program-targeted crops than women.

Senior Men

Forty seven percent of senior men (n=7) in the GLAM villages of cluster 3 reported using the advisories to inform their agricultural decisions. Of these men, 43% (n=3) demonstrated a working knowledge of the program, making them more likely to be using the program.

In cluster 3, senior men in GLAM villages cultivated an average of 5.1 crops, more than the 3.4 crops seen in former GLAM villages, but quite similar to the five crops in control villages. Figure A39 compares the crop selection preferences of senior and junior men in this cluster across GLAM, former GLAM, and control villages. Senior men in both GLAM and former GLAM villages emphasized program-targeted crops in their crop selection, with the only real difference between them a greater focus on cowpeas among those in GLAM villages. Senior men in control villages grew all five targeted crops as well, but their crop selections mixed more non-GLAM crops onto their farms than in either GLAM or former GLAM villages. The largest percentage of senior men growing cotton and peanuts were found in GLAM villages, with declining emphasis across former GLAM and control contexts.

**GLAM senior man**

| | |
|---|---|
| Avg # crops | 5.1 |
| Cotton | 100.00% |
| Sorghum | 100.00% |
| Maize | 86.67% |
| Peanut | 66.67% |
| Cowpeas | 60.00% |
| Millet | 33.33% |
| Rice | 20.00% |
| Sesame | 20.00% |
| Fonio | 13.33% |
| Sweet potato | 13.33% |

**Former GLAM senior man**

| | |
|---|---|
| Avg # crops | 3.4 |
| Sorghum | 100.00% |
| Cotton | 80.00% |
| Maize | 60.00% |
| Peanut | 50.00% |
| Millet | 20.00% |
| Fonio | 20.00% |
| Cowpeas | 10.00% |

**Control Senior Man**

| | |
|---|---|
| Avg # crops | 5.0 |
| Sorghum | 100.00% |
| Maize | 100.00% |
| Sesame | 80.00% |
| Cotton | 60.00% |
| Sweet potato | 60.00% |
| Peanut | 40.00% |
| Cowpeas | 40.00% |
| Millet | 20.00% |

**Figure A39: The crop selection preferences of senior men in cluster 3.**

Figure A40 shows only very small differences in crop selection between all senior men in GLAM villages and those that are likely to be using the advisories. The farmers clearly using the advisories downplayed

**Table A3: All crops grown in cluster 3, by subgroup and GLAM/former GLAM/control village.**

peanuts relative to all those in GLAM villages, but otherwise selection is quite similar. This diminished participation in peanut cultivation made the rates of GLAM peanut selection more similar to that in former GLAM and control villages than the larger group of all senior men in GLAM villages.

**GLAM Senior Man: All**

| | |
|---|---|
| Avg # crops | 5.1 |
| Cotton | 100.00% |
| Sorghum | 100.00% |
| Maize | 86.67% |
| Peanut | 66.67% |
| Cowpeas | 60.00% |
| Millet | 33.33% |
| Rice | 20.00% |
| Sesame | 20.00% |
| Fonio | 13.33% |
| Sweet potato | 13.33% |
| Potato | 13.33% |

**GLAM Senior Man: Probable**

| | |
|---|---|
| Avg # crops | 4.9 |
| Cotton | 100.00% |
| Sorghum | 100.00% |
| Maize | 85.71% |
| Cowpeas | 71.43% |
| Peanuts | 57.14% |
| Rice | 42.86% |
| Millet | 28.57% |
| Fonio | 14.29% |
| Sweet Potato | 14.29% |
| Sesame | 14.29% |
| Potato | 14.29% |

**GLAM Senior Man: Definite**

| | |
|---|---|
| Avg # crops | 4.7 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 100.00% |
| Rice | 66.67% |
| Peanuts | 33.33% |
| Millet | 33.33% |
| Cowpeas | 33.33% |

**Figure A40: The crop selections of senior men in GLAM villages, by all, those claiming to use the advisories, and those that claim to use advisories and understand how the program works.**

The variety selections of senior men in cluster 3 suggest some influence from the advisories (Figure A41). For example, at the community scale, senior men in GLAM villages distributed their variety selections across a range of cycles, generally emphasizing varieties with cycles in the middle of the distribution that conformed with the advisories. In former GLAM and control villages these men tended to emphasize varieties at one end of the distribution, sometimes with hedging through shorter and longer varieties. However, in former GLAM villages the entire sample of senior men picked a single cotton variety, and in the control villages senior men picked a single variety of cotton, peanuts, and millet. In both cases, these selections suggest that at the community level these men were all exposed to climate variability, as they were planting single varieties of each crop. It is worth noting that advisories do not discuss different varieties of cotton when advising farmers when to plant.

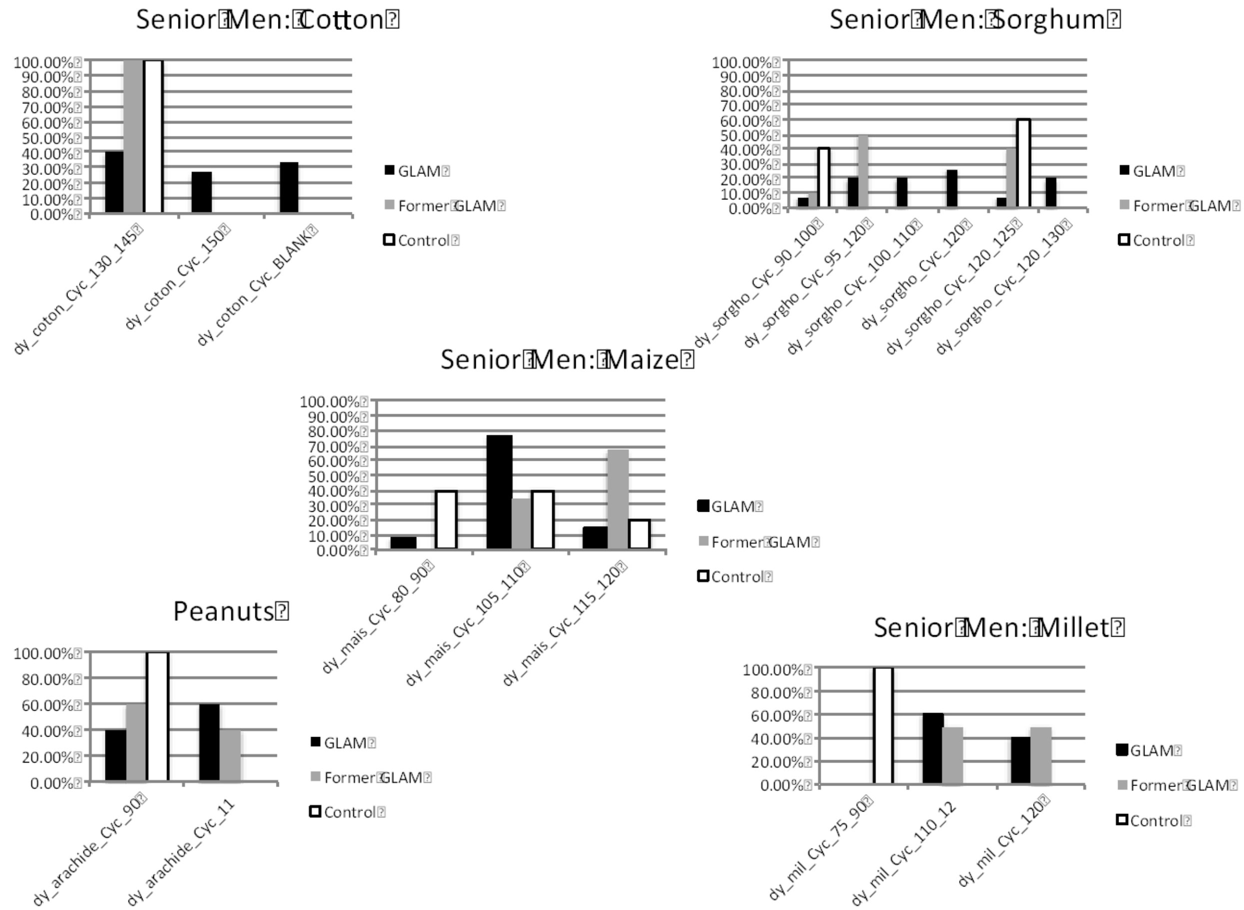



**Figure A41: Charts representing variety selection for the five advisory-informed crops across the village types.**

Only 20% of the senior men in this cluster were likely to be using the advisories. Separating those who definitely uses the advisories from the general GLAM population of senior men generated some shifts in patterns of variety selection. Figure A42 demonstrates that those using the advisories selected longer-cycle varieties of sorghum and maize than the wider group of senior men in GLAM villages, perhaps suggesting that these men followed the advisories as soon as they saw 10mm of rainfall during a dekad in May, and planted the longer-cycle varieties while their non-user counterparts waited until they were certain of the rainfall, and were forced into somewhat shorter-cycle varieties. Those using the advisories also selected shorter-cycle peanut varieties than all GLAM senior men as a whole. While seemingly contrary to the trend in sorghum and maize, peanut variety selection likely reflects an effort to time production to harvest during the hungry season, when prices are highest (these men sell peanuts, but use sorghum and maize as subsistence crops – see discussion below). While these shifts help distinguish possible advisory impacts within GLAM villages, they also reduce the apparent differences in selection between those using advisories and those without access to the advisories, calling into question the larger value of this information in variety selection.

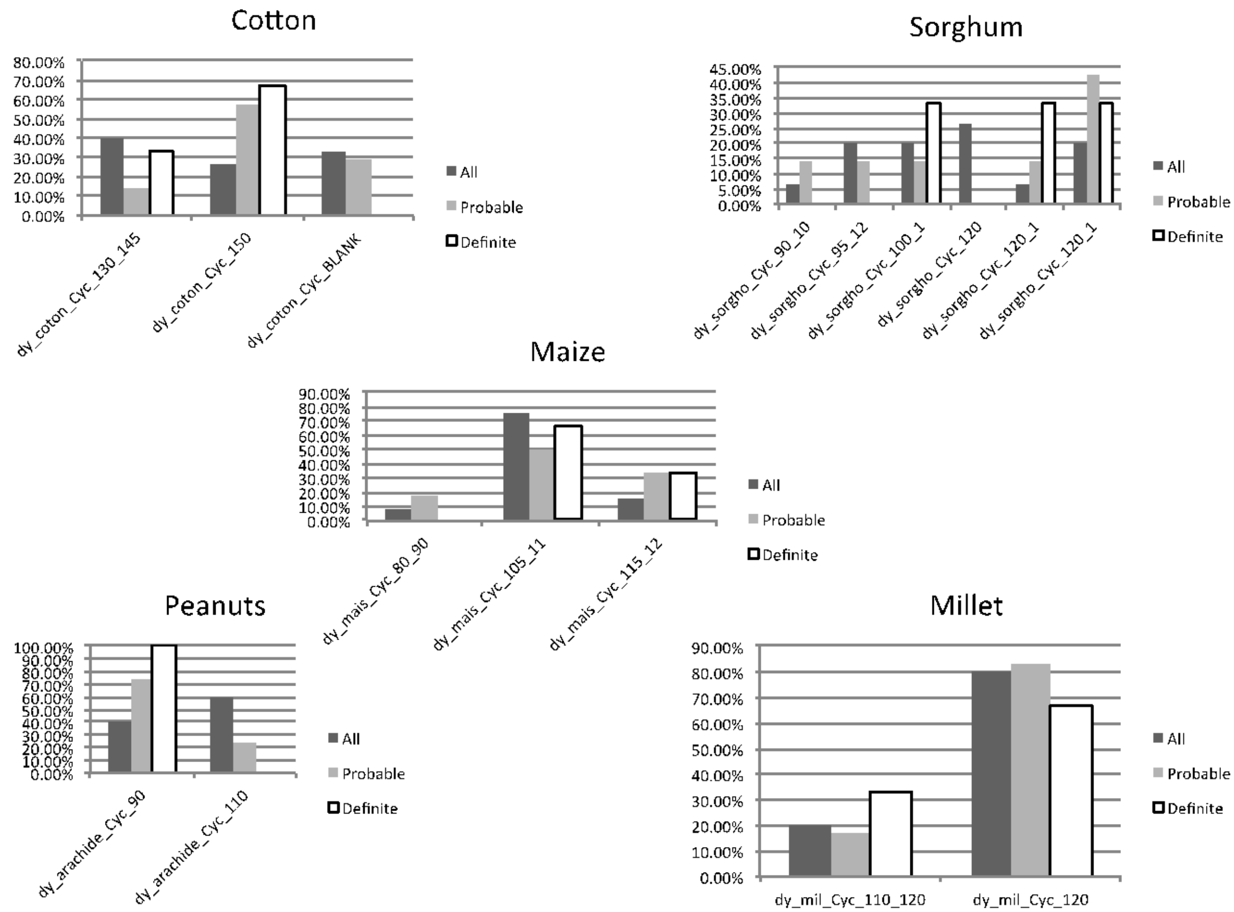



**Figure A42: Comparisons of variety selection among senior men in GLAM villages, comparing all such men, those that claimed to be using the advisories, and those that used the advisories and accurately reported the workings of the program.**

Figure A43 illustrates the purposes senior men had behind planting each of their crops. In GLAM and former GLAM villages, cotton served as a principal cash crop. Sorghum was clearly animal feed, and thus as not really a subsistence crop as much as an input into livestock husbandry that provided an alternate source of income. Cotton and sorghum aside, senior men in these villages also viewed peanuts and sesame (the latter grown only in GLAM villages, and very infrequently) as for sale, with all other crops grown for subsistence. In GLAM and former GLAM villages market engagement is the core of the agricultural strategy, supported by subsistence production. In control villages, agricultural strategy was quite different. The two most common crops are maize and sorghum, and both were cultivated for subsistence. There was also a significant market component to these strategies, as 80% of farms contained sesame, and 60% grew cotton, both crops that are principally useful for sale on local markets. The remaining crops are subsistence products. Therefore, in control villages agriculture was subsistence-first, with market engagement a secondary strategy.

**GLAM senior man**

| | |
|---|---|
| Cotton | Sell all |
| Sorghum | Eat all |
| Maize | Eat all |
| Peanut | Eat more than sell |
| Cowpeas | Eat all |
| Millet | Eat all |
| Rice | Eat all |
| Sesame | Sell all |
| Fonio | Eat all |
| Sweet potato | Eat all |

**Former GLAM senior man**

| | |
|---|---|
| Sorghum | Eat all |
| Cotton | Sell all |
| Maize | Eat all |
| Peanut | Eat and sell equally |
| Millet | Eat all |
| Fonio | Eat all |

**Control Senior Man**

| | |
|---|---|
| Sorghum | Eat all |
| Maize | Eat all |
| Sesame | Sell more than eat |
| Cotton | Sell more than eat |
| Sweet potato | Eat all |
| Peanut | Eat all |
| Cowpeas | Eat all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A43: Intended uses of all crops on two or more senior men's farms for cluster 3.**

The differences among the livelihoods of senior men across these three villages reflect different understandings of the vulnerability context, and perhaps different capacities to address the challenges of the vulnerability context. It is interesting that senior men in both GLAM and former GLAM villages listed numerous livelihoods challenges, while those in control villages listed relatively few. It may be that the subsistence-first strategy of control villages yielded a more predictable and reliable outcome year-to-year than did a strategy centered on market engagement, which opened up producers to a wider set of uncertainties and shocks.

Junior Men

Sixty percent (n=9) of the junior men in GLAM villages in this cluster reported using the advisories. Of these, 56% (n=5) demonstrated a working knowledge of the program and advisories, making it likely they were actually using the program in their agricultural decision-making.

In cluster 3, junior men in GLAM villages grew an average of 5.1 crops, similar to the 4.7 crops on junior men's farms in former GLAM villages and the 5.8 crops on farms in control villages (Figure A44). Very little distinguished the crop selections of those in GLAM and former GLAM villages. More junior men in GLAM villages grew millet, and slightly more grew cotton, than in former GLAM or control villages.

**GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 5.43 |
| Cotton | 100.00% |
| Sorghum | 100.00% |
| Maize | 85.71% |
| Peanut | 71.43% |
| Millet | 71.43% |
| Cowpeas | 71.43% |
| Rice | 21.43% |
| Fonio | 14.29% |
| Sesame | 7.14% |

**Former GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 4.70 |
| Sorghum | 90.00% |
| Cotton | 70.00% |
| Maize | 70.00% |
| Peanut | 70.00% |
| Cowpeas | 70.00% |
| Millet | 50.00% |
| Sesame | 30.00% |
| Fonio | 10.00% |
| Hibiscus | 10.00% |

**Control Junior Man**

| | |
|---|---|
| Avg # crops | 5.80 |
| Sorghum | 100.00% |
| Maize | 100.00% |
| Peanut | 100.00% |
| Cotton | 80.00% |
| Cowpeas | 40.00% |
| Sesame | 40.00% |
| Sweet potato | 40.00% |
| Millet | 20.00% |
| Rice | 20.00% |
| Papaya | 20.00% |
| Soy | 20.00% |

**Figure A44: The crop selection preferences of junior men in cluster 3.**

Figure A45 suggests there was little difference between the crop selections of those definitely using the advisories from the selections of all junior men in GLAM villages, though fewer of those using the advisories cultivated peanuts. This also suggests that those using the advisories cultivated peanuts far less frequently than junior men in former GLAM or control villages.

**GLAM Junior Man: All**

| | |
|---|---|
| Avg # crops | 5.4 |
| Cotton | 100.00% |
| Sorghum | 100.00% |
| Maize | 85.71% |
| Peanuts | 71.43% |
| Millet | 71.43% |
| Cowpeas | 71.43% |
| Rice | 21.43% |
| Fonio | 14.29% |
| Sesame | 7.14% |

**GLAM Junior Man: Probable**

| | |
|---|---|
| Avg # crops | 5.6 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 100.00% |
| Peanuts | 75.00% |
| Millet | 75.00% |
| Cowpeas | 75.00% |
| Rice | 25.00% |
| Fonio | 12.50% |

**GLAM Junior Man: Definite**

| | |
|---|---|
| Avg # crops | 5.0 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 100.00% |
| Millet | 75.00% |
| Cowpeas | 75.00% |
| Peanuts | 50.00% |

**Figure A45: The crop selections of junior men in GLAM villages, by all, those claiming to use the advisories, and those that claim to use advisories and understand how the program works.**

The sorghum, cotton, and maize variety selections of junior men's provides some evidence of advisory use (Figure A46). Junior men in GLAM villages distributed their variety selections across a range of cycles, but displayed a general tendency to select shorter-cycle varieties across GLAM crops than those in former GLAM and control villages. Those in former GLAM villages selected longer-cycle varieties of sorghum and millet than those in GLAM villages. Junior men in control villages selected longer-cycle varieties of sorghum, millet, and peanuts. As the selections of junior men in GLAM villages conformed with the advisories, it appears that many of those without access to the advisories may have been overconfident in their cycle selection due to the above-normal rainfall in mid- and late May.

Nearly all individual farmers focused on the cultivation of a single variety on their farms, exposing their farms and households to a great deal of risk. This suggests that the advisories are not changing this aspect of variety selection, and indeed their highly-focused advice is likely guiding farmers toward a single variety instead of a range of varieties.

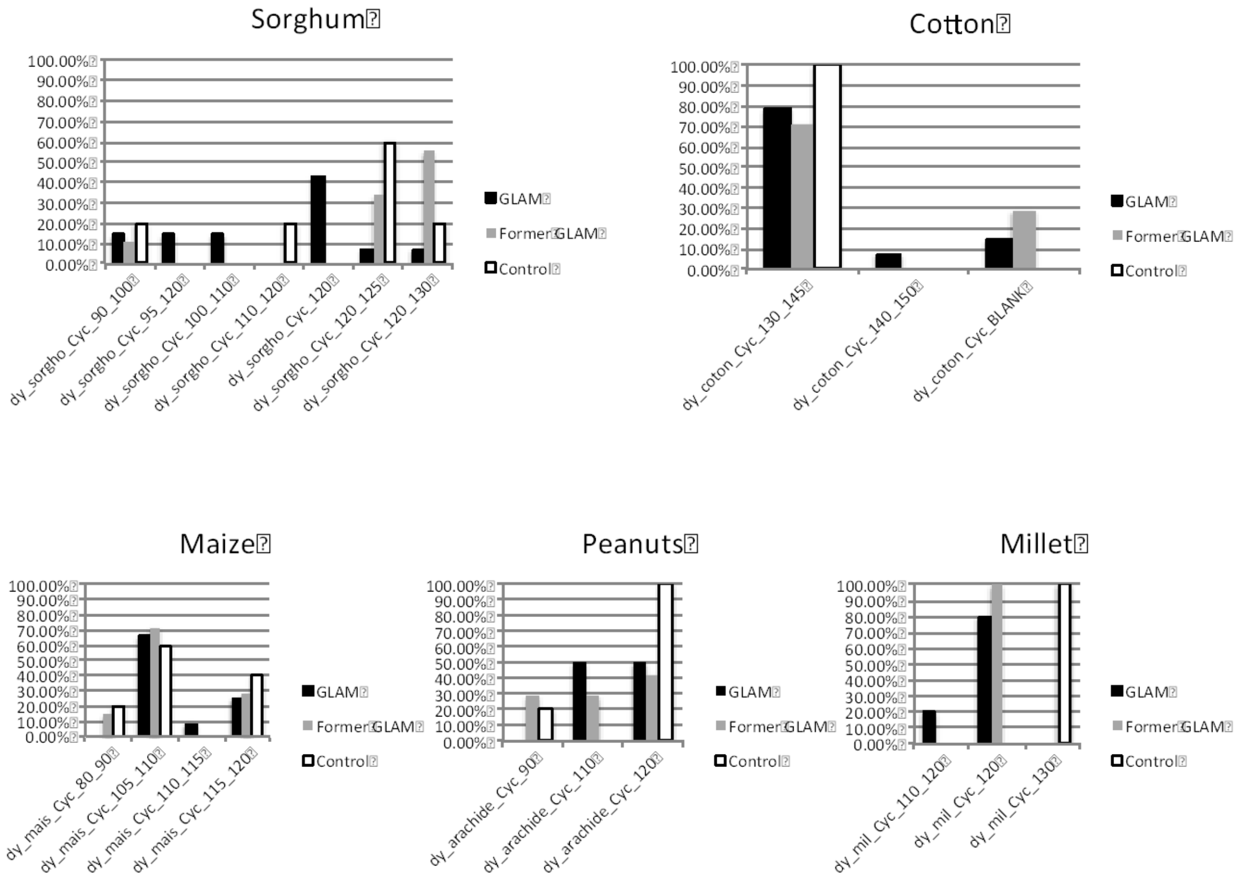



**Figure A46: Charts representing variety selection for the five advisory-informed crops across the village types.**

Figure A47 shows that the selections of those definitely using the advisories were clustering their selections on the same or somewhat longer cycles than GLAM men in general. However, this longer-cycle emphasis remains shorter than that seen in villages without access to the advisories, and reflects an apparent close adherence to the advisories when making variety selections.

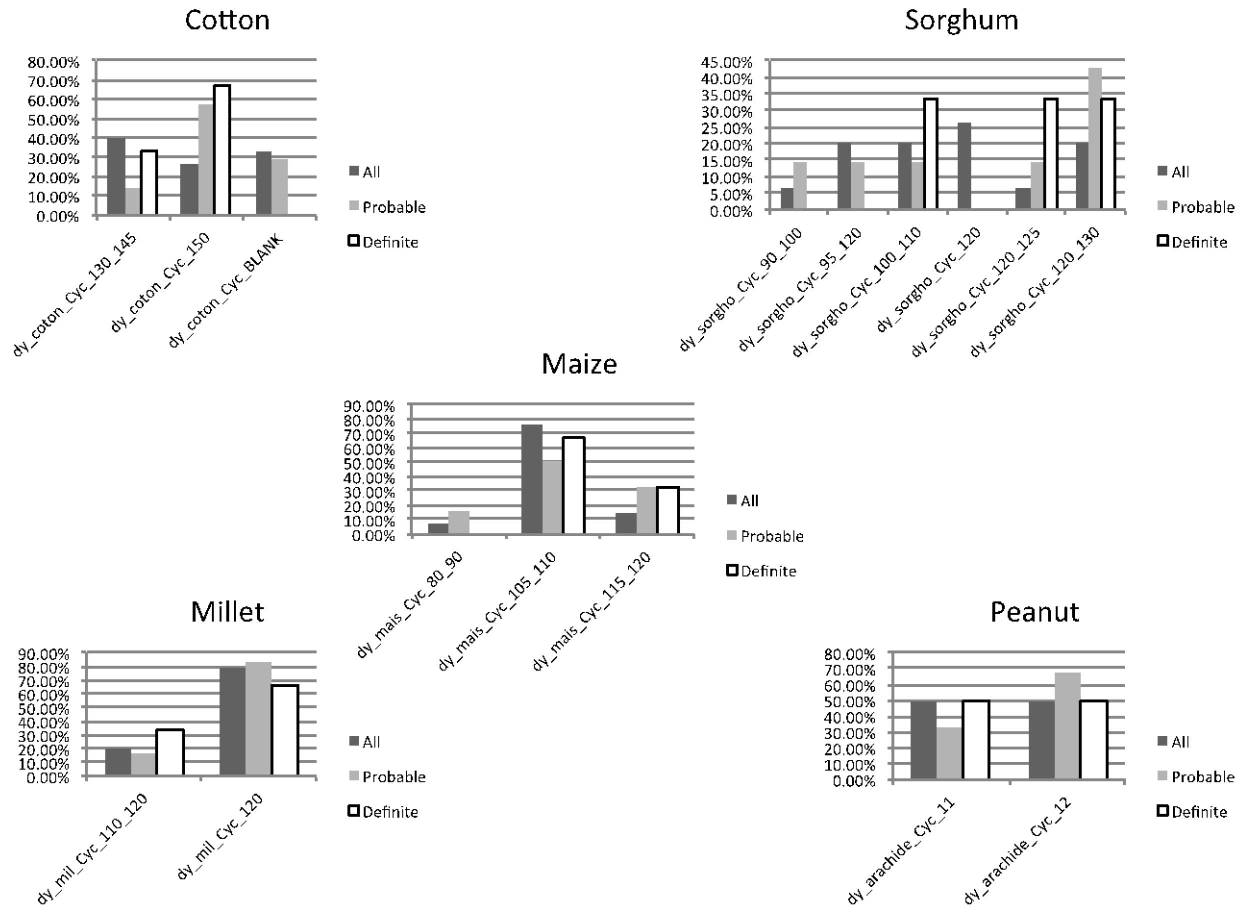



**Figure A47: Comparisons of variety selection among junior men in GLAM villages, comparing all such men, those that claimed to be using the advisories, and those that used the advisories and accurately reported the workings of the program.**

Figure A48 illustrates the purpose for planting each crop on these farms. This figure suggests that junior men operated with very similar agricultural strategies regardless of access to the advisories. Junior men in GLAM villages clearly hinged their production on cotton, with sorghum raised to feed their livestock. All other crops were subsistence crops whose surplus harvests were sold. Junior men in former GLAM and control villages had a similar core to their agricultural strategies, but those in former GLAM villages seemed confident in their ability to generate marketable surpluses of their staple crops. For example, they saw peanuts as much more for sale than do those in GLAM villages.

**GLAM Junior Man**

| Crop | Intended use |
|---|---|
| Cotton | Sell all |
| Sorghum | Eat all |
| Maize | Eat more than sell |
| Peanut | Eat more than sell |
| Millet | Eat more than sell |
| Cowpeas | Eat more than sell |
| Rice | Eat all |
| Fonio | Eat and sell equally |

**Former GLAM Junior Man**

| Crop | Intended use |
|---|---|
| Sorghum | Eat all |
| Cotton | Sell all |
| Maize | Eat more than sell |
| Peanut | Sell more than eat |
| Cowpea | Eat and sell equally |
| Millet | Eat all |
| Sesame | Sell more than eat |

**Control Junior Man**

| Crop | Intended use |
|---|---|
| Sorghum | Eat all |
| Maize | Eat all |
| Peanut | Eat more than sell |
| Cotton | Sell all |
| Cowpeas | Eat and sell equally |
| Sesame | Sell all |
| Sweet potato | Sell more than eat |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A48: Intended uses of all crops on two or more junior men's farms for cluster 3.**

In summary, junior men in cluster 3 practiced similar agricultural strategies, focused on market production buffered by subsistence staple cultivation. Those in GLAM villages, including those who are clearly using the advisories, selected shorter cycles of maize, peanuts, and millet than those without access to the advisories. These men had the least diversified livelihoods of all junior men. In control villages this longer cycle selection, which will yield larger harvests in good years, might have been enabled by hedging agricultural production with hand-irrigated gardening, in which roughly 40% of junior men participated. Those in former GLAM and control villages also had somewhat higher rates of engagement with livestock husbandry than those in GLAM villages, further diversifying their livelihoods and perhaps explaining the higher rate of peanut cultivation in these villages. Peanut plants can be used for fodder, and the selection of longer-cycle varieties makes the storage of late-harvested plants for fodder more feasible that for plants harvested during the rains. The livelihoods of only a few junior men in GLAM and former GLAM villages were diversified through engagement with trade.

Senior women

Thirty-three percent (n=5) of senior women in GLAM villages reported using the advisories in this cluster. Of those reporting use of the advisories, all demonstrated knowledge of the program and advisories that suggests they are, in fact, using the advisories to inform their agricultural practices. This number is only slightly larger than the 27% of senior women (n=4) who argued that the advisories were only for men.

In cluster 3, senior women in control villages grew an average of 5.53 crops (Figure A49). This was very similar to the average of 4.44 crops in former GLAM villages, and 5.2 crops in control villages. Peanuts and rice were the foundation of agricultural production for senior women in this cluster. Around these crops, women planted a variety of gardened vegetables. With the exception of peanuts, GLAM crops were generally cultivated by less than 25% of women in any village type, with the exception of senior women in control villages. Eighty percent of these women grew maize. This represented a somewhat different composition of crop selection for control women, who emphasized rain fed crops over irrigated vegetables in a manner not seen on GLAM or former GLAM farms.

**GLAM Senior Woman**

| | |
|---|---|
| Avg # crops | 5.5 |
| Peanut | 93.33% |
| Rice | 93.33% |
| Onion | 73.33% |
| Okra | 66.67% |
| Cowpeas | 60.00% |
| Lettuce | 46.67% |
| Fonio | 26.67% |
| Maize | 26.67% |
| Tomato | 20.00% |
| Chili pepper | 13.33% |
| Eggplant | 6.67% |
| Cabbage | 6.67% |
| Mint | 6.67% |
| Hibiscus | 6.67% |
| Bambara nuts | 6.67% |

**Former GLAM senior Woman**

| | |
|---|---|
| Avg # crops | 4.3 |
| Peanut | 88.89% |
| Rice | 66.67% |
| Okra | 55.56% |
| Cowpeas | 44.44% |
| Millet | 33.33% |
| Onion | 22.22% |
| Fonio | 22.22% |
| Maize | 22.22% |
| Sorghum | 22.22% |
| Lettuce | 11.11% |
| Tomato | 11.11% |
| Banana | 11.11% |
| Cotton | 11.11% |
| Papaya | 11.11% |

**Control Senior Woman**

| | |
|---|---|
| Avg # crops | 5.2 |
| Peanut | 100.00% |
| Rice | 80.00% |
| Maize | 80.00% |
| Okra | 60.00% |
| Chili pepper | 40.00% |
| Cassava | 40.00% |
| Cowpeas | 20.00% |
| Lettuce | 20.00% |
| Baobob | 20.00% |
| Papaya | 20.00% |
| Sesame | 20.00% |
| Sorghum | 20.00% |

**Figure A49: The crop selection preferences of senior women in cluster 3.**

Figure A50 demonstrates that there was very little difference in GLAM crop selection, or indeed crop selection in general, between those using the advisories and all senior women in GLAM villages.

**GLAM Senior Woman: All**

| | |
|---|---|
| Avg # crops | 5.5 |
| Peanut | 93.33% |
| Rice | 93.33% |
| Onion | 73.33% |
| Okra | 66.67% |
| Cowpeas | 60.00% |
| Lettuce | 46.67% |
| Fonio | 26.67% |
| Maize | 26.67% |
| Tomato | 20.00% |
| Chili pepper | 13.33% |
| Eggplant | 6.67% |
| Cabbage | 6.67% |
| Mint | 6.67% |
| Hibiscus | 6.67% |
| Bambara nuts | 6.67% |

**GLAM Senior Woman: Definite**

| | |
|---|---|
| Avg # crops | 5.6 |
| Peanuts | 100.00% |
| Okra | 100.00% |
| Onion | 100.00% |
| Rice | 100.00% |
| Fonio | 60.00% |
| Cowpeas | 40.00% |
| Lettuce | 20.00% |
| Maize | 20.00% |
| Tomato | 20.00% |

**Figure A50: The crop selections of senior women in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

The variety selections of senior women in this cluster offer limited value in evaluating the potential impact of climate information on their strategies (Figure A51). There was little difference in the community-level distribution of peanut variety selection across the three village types. While for maize there were some differences in cycle-length selection across village types, in all village types there was a clear spreading of varieties across longer and shorter cycles. However, women in GLAM villages focused on 120-day cycle varieties, which conformed with the advisories, where senior women in other villages generally were selecting somewhat shorter cycle varieties. Women in GLAM villages selected shorter-cycle peanut varieties than their husbands in a clear deviation from the advisories. It is not clear, with the evidence at hand, what informed this selection. Because senior women sell this crop, they may have been trying to set up an early harvest to maximize market prices, or they may not have been able to plant their peanuts in a timely manner as they waited on men's labor, forcing them into later advisories and shorter cycles. It is difficult to meaningfully interpret sorghum variety selection between former GLAM and control villages, as this was a relatively uncommon crop in both settings. It is interesting to note that the variety selections of these women only loosely resembled those of senior or junior men in the same villages. It is not clear if this means that women in this cluster were independently obtaining seeds, and therefore able to independently act on advisories.

At the individual farmer level, almost all senior women focused on the cultivation of a single variety of each crop they cultivated (the exception here being the 20% of senior women in control villages who plant both short and long cycle peanuts). Whether the advisories were informing women's variety selections or not, they were not changing a wider pattern of reliance on a single variety, and in this regard did little to alleviate vulnerability to climate variability for those senior women using the advisories in this cluster.

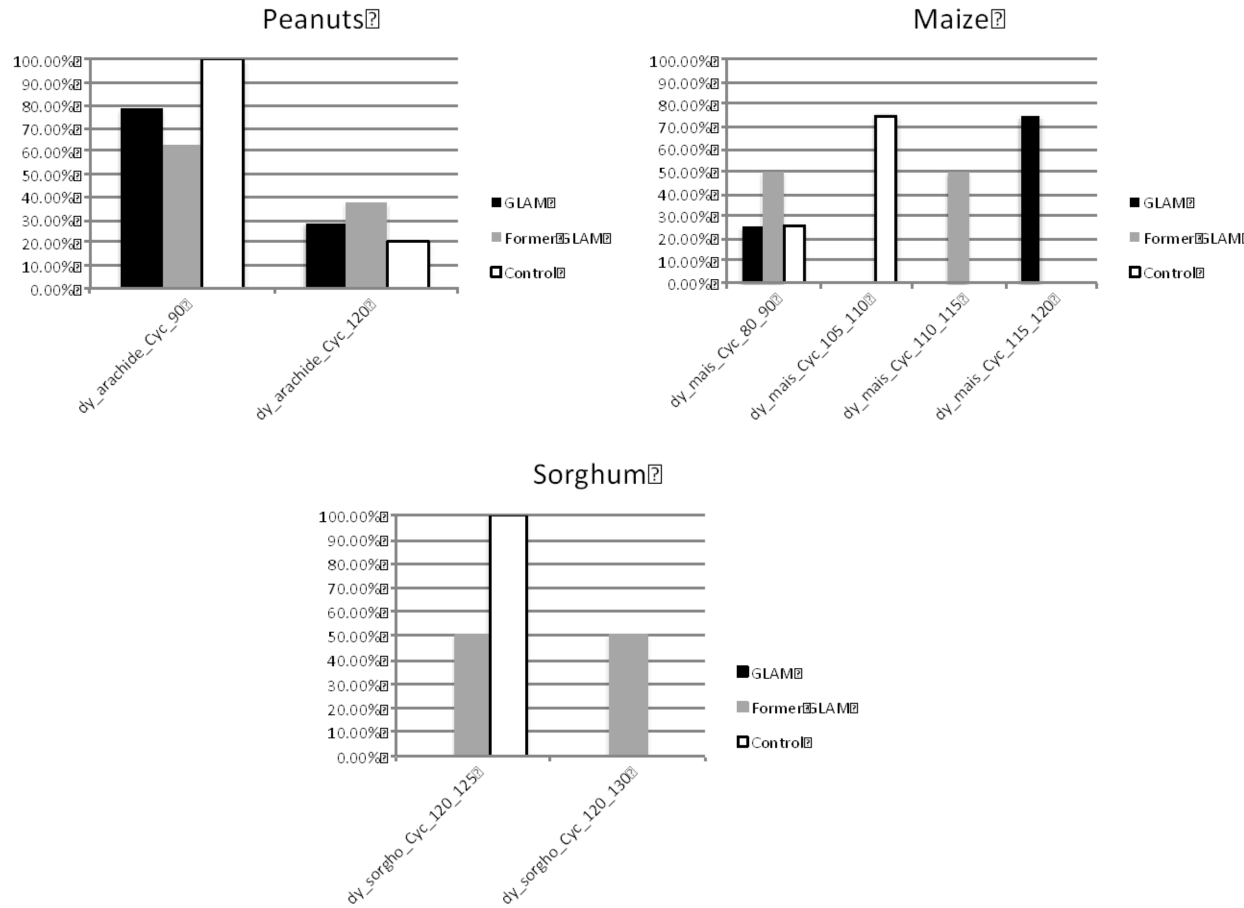



**Figure A51: Charts representing variety selection for the three advisory-informed crops for which there were significant selection differences across the village types.**

Figure A52 shows that women who used the advisories focused on shorter-cycle varieties than did senior women in GLAM villages on the whole. These women were focused on much shorter cycles of maize than women who were not using the advisories. This runs contrary to the advisories, and suggests that women were not able to plant their own crops in a timely manner or lacked access to longer-cycle seeds.

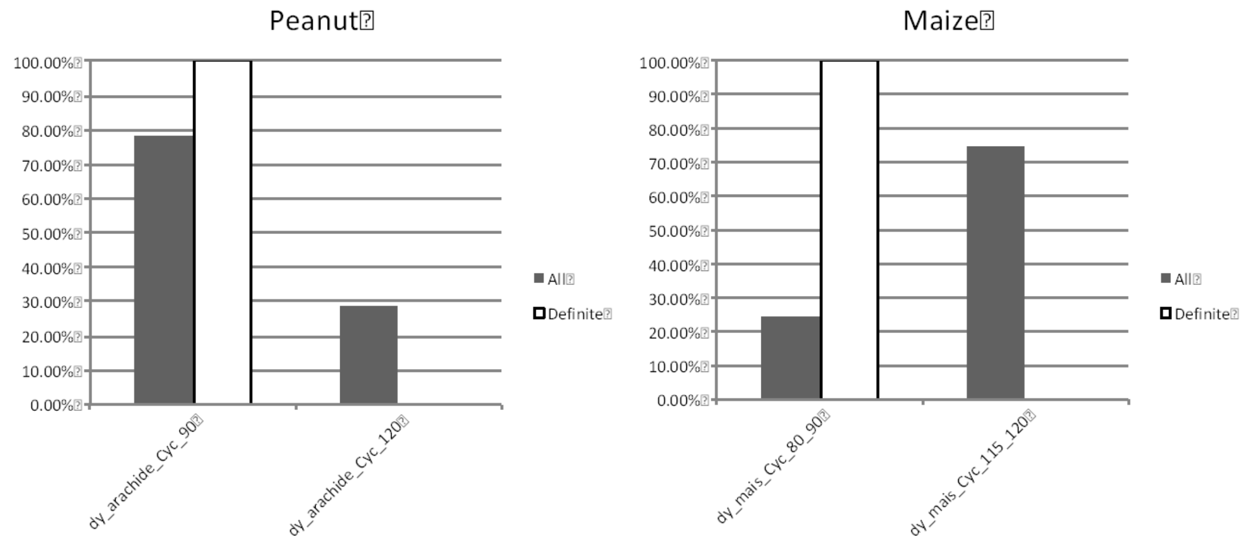



**Figure A52: Comparisons of variety selection among senior women in GLAM villages, comparing all such women and those that used the advisories and accurately reported the workings of the program.**

Figure A53 displays senior women's motivations for planting different crops in cluster 3, and shows that there were different agricultural strategies in play across the three village types. Senior women in GLAM villages were more focused on market production than their former GLAM or control counterparts. Senior women in former GLAM villages marketed any surplus of peanuts, and clearly cultivated okra for sale but all of their other crops were for household consumption. In control villages, all crops grown by senior women were principally for household consumption, with market engagement coming through the sale of any surplus production (except for chili peppers, which 40% of these women grew with the intent of selling them at market).

**GLAM Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Rice | Eat all |
| Onion | Sell more than eat |
| Okra | Eat and sell equally |
| Cowpeas | Eat more than sell |
| Lettuce | Sell all |
| Fonio | Eat and sell equally |
| Maize | Eat all |
| Tomato | Sell all |
| Chili pepper | Sell all |

**Former GLAM Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Rice | Eat all |
| Okra | Sell more than eat |
| Cowpeas | Eat all |
| Millet | Eat all |
| Onion | Eat all |
| Fonio | Eat all |
| Maize | Eat all |
| Sorghum | Eat all |

**Control Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Rice | Eat more than sell |
| Maize | Eat all |
| Okra | Eat more than sell |
| Chili pepper | Sell more than eat |
| Cassava | Eat more than sell |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A53: Intended uses of all crops on two or more senior women's farms for cluster 3.**

The broader livelihoods activities of senior women in these different villages help explain a great deal of the observed differences in agricultural strategy. Senior women in GLAM villages participated in livestock husbandry at roughly half the rate of senior women in former GLAM or control villages, and had somewhat lower rates of participation in gathering/picking. Therefore, much more of their personal income and livelihoods assets were linked to their farms, which helps to explain their greater market focus in their agricultural strategy. Senior women in former GLAM villages did not participate in business/trade at all, removing much of the incentive for market orientation on their farms. Senior women in control villages had the highest rates of participation in gathering/picking, and all of these women owned livestock. Yet they also had rates of participation in trading and gardening that were roughly the same as those in GLAM villages. These women appear to have been balancing subsistence agricultural production and market engagement, perhaps to manage the wide range of stresses and shocks they faced in this vulnerability context.

Junior women

One third (n=5) of junior women in GLAM villages in cluster 3 reported using the advisories. Of these women, only 40% (n=2) reported a functional understanding of the program and advisories, suggesting that the number of junior women actually using the advisories is very small. Further, one junior women in a GLAM village argued that the advisories were for men, not women.

In cluster 3, junior women in GLAM villages raised an average of 6.8 crops, a number similar to that in former GLAM villages (5.9 crops) but very different from the remarkable 10.4 crops grown by junior women in control villages (Figure A54). Across all village types, peanuts and okra are clearly the crops junior women emphasized, but after these two crops there was quite a bit of variation. Significant engagement with gardening drove up the average number of crops, and also the total number of crops, grown in each village type. Peanuts were the only commonly-grown crop of junior women that have agrometeorological advisories, though 40% of junior women in former GLAM villages also raised maize. All other cultivation of GLAM crops was extremely limited. For the vast majority of the crops grown by these women, advisories were of little use because the crops are hand irrigated and therefore quite resilient in the face of variable precipitation.

**GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 6.67 |
| Peanut | 100.00% |
| Okra | 93.33% |
| Rice | 66.67% |
| Onion | 66.67% |
| Lettuce | 66.67% |
| Chili pepper | 46.67% |
| Cowpeas | 40.00% |
| Bambara nuts | 33.33% |
| Hibiscus | 33.33% |
| Fonio | 26.67% |
| Eggplant | 26.67% |
| Tomato | 26.67% |
| Bell Pepper | 13.33% |
| Sorghum | 13.33% |
| Cabbage | 6.67% |
| Millet | 6.67% |

**Former GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 6.10 |
| Peanut | 100.00% |
| Okra | 80.00% |
| Rice | 80.00% |
| Onion | 70.00% |
| Fonio | 50.00% |
| Maize | 40.00% |
| Cowpeas | 30.00% |
| Eggplant | 30.00% |
| Lettuce | 20.00% |
| Chili pepper | 20.00% |
| Tomato | 20.00% |
| Cabbage | 20.00% |
| Bambara nuts | 10.00% |
| Bell Pepper | 10.00% |
| Sorghum | 10.00% |
| Papaya | 10.00% |
| Cotton | 10.00% |

**Control Junior Woman**

| | |
|---|---|
| Avg # crops | 10.40 |
| Peanut | 100.00% |
| Okra | 100.00% |
| Onion | 100.00% |
| Chili pepper | 100.00% |
| Cowpeas | 100.00% |
| Bambara nuts | 100.00% |
| Eggplant | 100.00% |
| Hibiscus | 80.00% |
| Tomato | 80.00% |
| Cassava | 80.00% |
| Lettuce | 40.00% |
| Papaya | 40.00% |
| Rice | 20.00% |

**Figure A54: The crop selection preferences of junior women in cluster 3.**

As Figure A55 illustrates, there was little difference in the crop selections of those definitely using the advisories and junior women in GLAM villages in general.

**GLAM Junior Woman: All**

| | |
|---|---|
| Avg # crops | 6.7 |
| Peanut | 100.00% |
| Okra | 93.33% |
| Rice | 66.67% |
| Onion | 66.67% |
| Lettuce | 66.67% |
| Chili pepper | 46.67% |
| Cowpeas | 40.00% |
| Bambara nuts | 33.33% |
| Hibiscus | 33.33% |
| Fonio | 26.67% |
| Eggplant | 26.67% |
| Tomato | 26.67% |
| Bell Pepper | 13.33% |
| Sorghum | 13.33% |
| Cabbage | 6.67% |
| Millet | 6.67% |

**GLAM Junior Woman: Probable**

| | |
|---|---|
| Avg # crops | 7.0 |
| Peanuts | 100.00% |
| Okra | 100.00% |
| Lettuce | 100.00% |
| Onion | 100.00% |
| Rice | 100.00% |
| Fonio | 80.00% |
| Cowpeas | 20.00% |

**GLAM Junior Woman: Definite**

| | |
|---|---|
| Avg # crops | 7.5 |
| Peanuts | 100.00% |
| Fonio | 100.00% |
| Okra | 100.00% |
| Lettuce | 100.00% |
| Onion | 100.00% |
| Rice | 100.00% |
| Cowpeas | 50.00% |

**Figure A55: The crop selections of junior women in GLAM villages, by all, those claiming to use the advisories, those claiming to use the advisories, and those that claim to use advisories and understand how the program works.**

The only clearly different variety selection associated with junior women in GLAM villages was the community-level focus on short-cycle sorghum varieties, versus the long-cycle emphasis in former GLAM villages (Figure A56). However, only one or two women in these cohorts cultivated sorghum, making this difference difficult to interpret. At the individual level, most of these women selected a single variety of each GLAM crop they planted. Junior women in both GLAM and control villages, however, planted both short and long-cycle peanuts, making their individual peanut cultivation substantially more resilient than seen in GLAM or former GLAM villages. The peanut variety selections of more than half of women in GLAM villages were much shorter than those recommended by the advisories, suggesting these women were either attempting to time local markets to maximize prices, or dealing with delayed planting (they did not list access to seeds as a problem in focus group discussions).

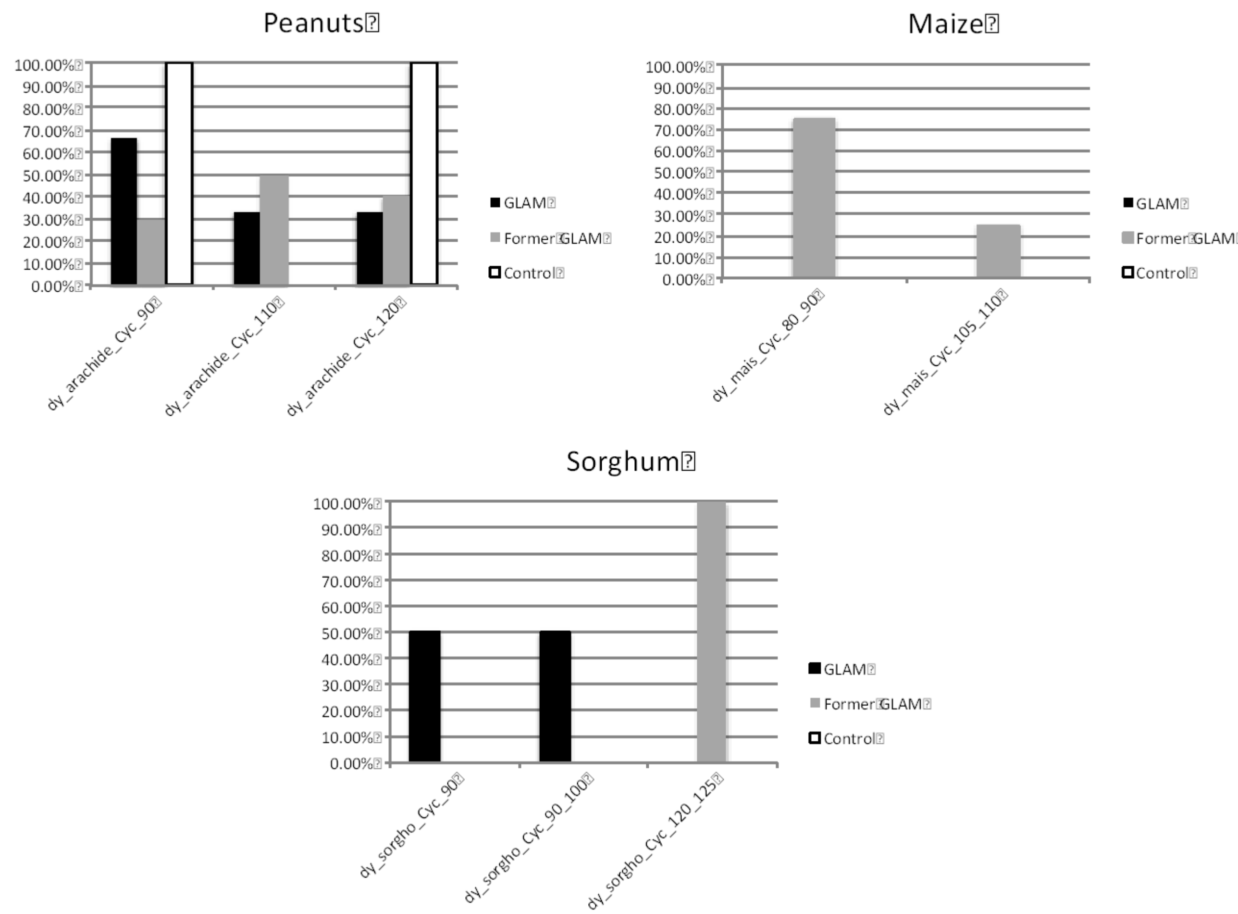



**Figure A56: Charts representing variety selection for the three advisory-informed crops for which there were significant selection differences across the village types.**

Figure A57 demonstrates that for peanuts (the only GLAM crop for which there was variable variety selection among junior women in GLAM villages), those using the advisories focused on cycles that conformed to the advisories, suggesting they had at least some capacity to use the information to inform their seed selections and agricultural activities. Critically, those using the advisories were not planting more than one variety. This suggests that those using the advisories were influenced by the single-cycle focused advice, and over-focused on a single cycle when they otherwise might have hedged with multiple cycles.

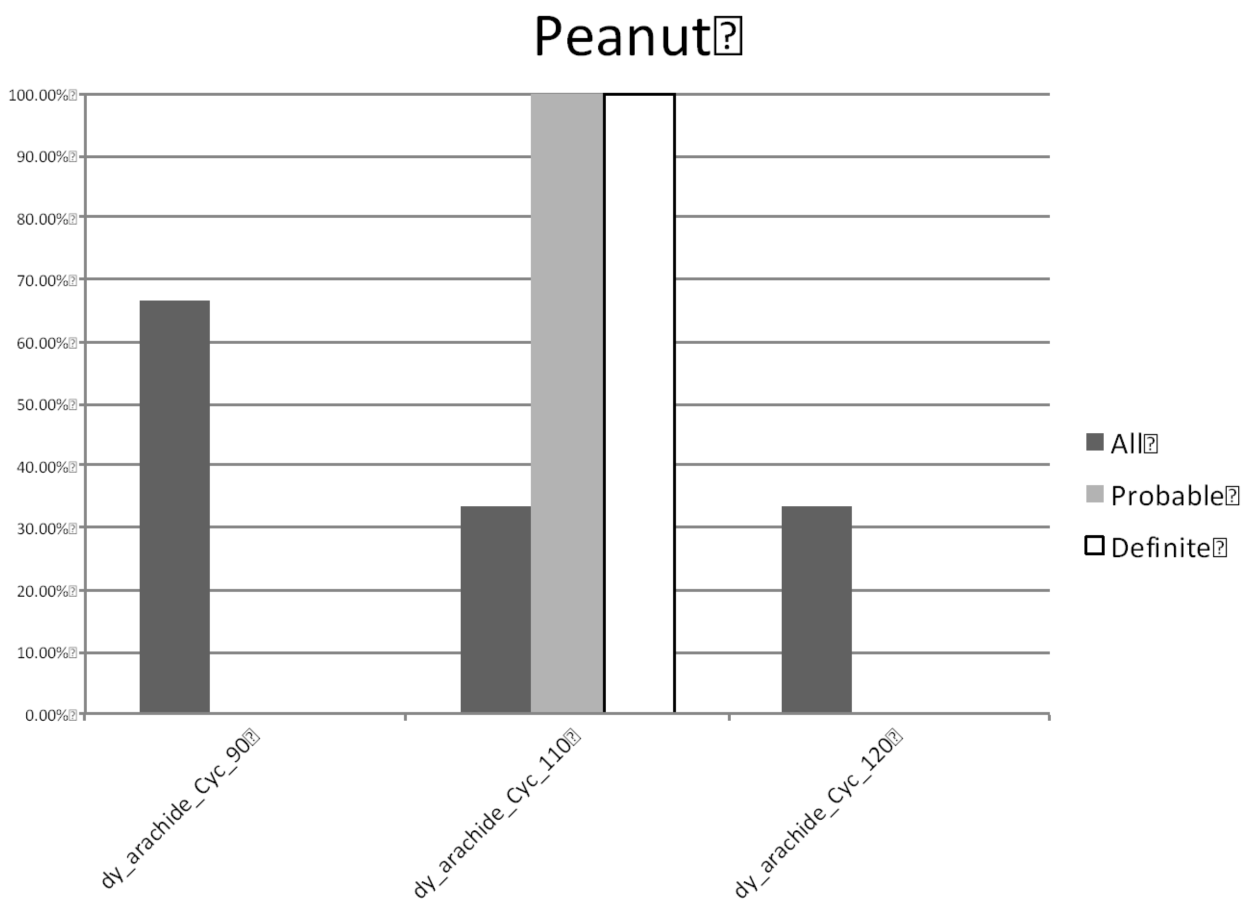



**Figure A57: Comparisons of peanut variety selection among junior women in GLAM villages, comparing all such women, those that claimed to be using the advisories, and those that used the advisories and accurately reported the workings of the program.**

Figure A58 illustrates junior women's reasons behind planting individual crops in each of the three village types. Junior women in GLAM villages, spreading their efforts across a wide range of crops, had perhaps the most conservative agricultural strategy in this cluster. They planted one or two crops for sale, using the rest as subsistence crops that were sold only when surpluses were present. Junior women in former GLAM villages expected a marketable surplus from a few more of their subsistence crops than their GLAM counterparts, but otherwise appear to have operated under a similar agricultural strategy. Junior women in control villages had a slightly greater market orientation, growing an average of roughly four crops for market sale, with the balance used for subsistence.

**GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat all |
| Okra | Eat more than sell |
| Rice | Eat all |
| Onion | Eat and sell equally |
| Lettuce | Eat and sell equally |
| Chili pepper | Eat and sell equally |
| Cowpeas | Eat all |
| Bambara nuts | Eat all |
| Hibiscus | Eat all |
| Fonio | Eat and sell equally |
| Eggplant | Eat more than sell |
| Tomato | Eat more than sell |
| Bell pepper | Sell more than eat |
| Sorghum | Eat all |

**Former GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Okra | Eat and sell equally |
| Rice | Eat all |
| Onion | Eat and sell equally |
| Fonio | Eat more than sell |
| Maize | Eat all |
| Cowpeas | Eat all |
| Eggplant | Sell all |
| Lettuce | Sell more than eat |
| Chili pepper | Sell all |
| Tomato | Eat and sell equally |
| Cabbage | Sell all |

**Control Junior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Okra | Eat all |
| Onion | Sell more than eat |
| Chili pepper | Sell more than eat |
| Cowpeas | Eat all |
| Bambara nuts | Eat all |
| Eggplant | Eat and sell equally |
| Hibiscus | Eat all |
| Tomato | Sell more than eat |
| Cassava | Eat and sell equally |
| Lettuce | Sell more than eat |
| Papaya | Sell more than eat |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A58: Intended uses of all crops on two or more senior women's farms for cluster 3.**

The different livelihoods activities of junior women in different villages helps explain some of the patterns of agricultural strategy observed in this cluster. Junior women in GLAM villages cultivated crops with expectations of marketable surpluses, and therefore engagement with markets in their strategy. They diversified this production with significant work in trade and business, though much of this was likely tied to the marketing of their own crops. In this way, the livelihoods of junior women in GLAM villages were quite similar to that in former GLAM and control villages. However junior women in GLAM villages had the lowest rate of participation in livestock husbandry. In former GLAM and control villages, junior women's greater engagement with livestock husbandry provided a store of wealth that served to buffer their livelihoods against stresses and shocks in the vulnerability context. Junior women in control villages also had the highest rates of gathering/picking and gardening, which seems to echo their agricultural strategy – gardening provided resilience against variable precipitation and access to cash income, while gathering/picking was principally a subsistence activity that served to meet household needs directly (except in the case of shea nuts, which have value in markets). In short, the livelihoods of junior women in cluster 3 are broadly similar, with the small differences in agricultural strategy largely explained by different rates of livestock husbandry, as opposed to access to agrometeorological advisories.

### 6.4.4. CLUSTER 3 SUMMARY

Possible Program Impacts

While the villages in cluster 3 received the same advisories as those in cluster 2, their variety selections worked out quite differently, especially for millet and sorghum. This is explained by the localization of the advisories through the rain gauges. Unlike cluster 2, the villages in cluster 3 received enough rain throughout May and likely early June, allowing them to plant the longer cycles suggested by early advisories. This explains why, in cluster 3, there is no divergence between the longer cycles of maize and peanut and the shorter cycle selections of millet and sorghum. In a general manner, this outcome speaks to the efficacy of using rain gauges to localize the broader advisories and inform agricultural decision-making in a locally-appropriate manner.

In cluster 3, the patterns of crop selection show little evidence of impact from the use of advisories. Junior men using the advisories appeared to emphasize millet and de-emphasize peanuts in their selections. However, within GLAM villages there was no such pattern among junior men using the advisories and those who were not. Further, senior men did not follow this pattern, either across villages or within GLAM villages, making it difficult to associate the selections of junior men with advisories. Similarly, senior women in control villages cultivated much more maize than those using the advisories, which might suggest that the advisories warned of conditions that would compromise maize. However, there was no such pattern between those junior women using the advisories and those who were not *within* GLAM villages, and no such pattern among senior women, making it unlikely that this pattern was a product of advisory use.

Variety selection provides suggestions of possible impacts. Senior men using advisories generally selected the varieties suggested by the advisories, giving them selections that were the same or longer cycles for maize, sorghum, and millet cycles than those in other villages. These same men planted shorter-cycle peanut varieties than recommended by the advisories. This may seem contradictory, but in fact it strongly suggests that these men were selecting peanut varieties not to manage seasonal variations in climate, but in an effort to time their harvest for the middle of the hungry season, when prices are highest. Junior men in GLAM villages followed this general pattern, but did not select short-cycle peanuts, perhaps because they were less concerned about marketing this staple than senior men. Within GLAM villages, there were small differences in variety selection between those men definitely using the advisories and the population at large, but in these cases those using the advisories generally selected longer-cycle varieties recommended by the advisories in a manner similar to that seen in communities where there was no access to advisories. While this suggests that the advisories do have an impact on variety selection, the fact these selections resemble those of farmers without advisories calls into question the value of these advisories relative to other forms of information the farmers might be using to inform their agricultural practices.

There are gendered differences in the potential and observed impacts of the advisories in this cluster. While men generally grow several GLAM crops, women in this cluster grew relatively few. With the exception of peanuts, most of the crops that women would deem important were gardened (and likely hand-irrigated), limiting the utility of the program for women. Further, because women did not cultivate many GLAM crops, there was little evidence from which to make variety selection comparisons. Where there was evidence for variety selection, there were few differences between those in GLAM villages and those in other villages. Within GLAM villages, junior women tended to conform to the advisories, suggesting a degree of capacity to use the advisories. Senior women, however, planted much shorter cycle varieties than seen in other villages. Further, these short-cycle varieties were not recommended by the advisories. This suggests that these women had less capacity to act on the advisories, perhaps because they did not have access to adequate seeds (a problem they listed in focus groups) and because they were delayed in planting by a household labor focus on men's farms.

Variety selection data generally displayed a worrying tendency toward the selection of a single variety of each GLAM crop for cultivation on their farms. Access to and use of the advisories did not change this pattern, though among junior women the use of advisories appears to have caused women to focus on a single peanut variety instead of distributing their selections across a range of cycles in a manner reflecting seasonal probabilities. This is to be expected, as the advisories generally recommended a single cycle without any discussion of probabilities or the distribution of risk across varieties. Unless there is a community-level mechanism for the distribution of risk associated with seasonal variability, all farmers in this cluster are all exposed to such variability, and might be using the advisories to create a false sense of confidence in a single variety.

1) Crop selection:
    a. There is little definitive evidence of advisory impact on crop selection in this cluster of villages.
2) Variety selection:
    a. Those using the advisories selected advisory-recommended varieties of all crops except in the case of senior men and peanuts
        i. Peanut selection was likely informed by efforts to time markets, rather than specific agrometeorological situations.
    b. Junior and Senior men who used the advisories had very similar patterns of variety selection.
        i. These patterns were often somewhat different than seen in GLAM villages as a whole.
        ii. However, these patterns were not very different from those seen in former GLAM and control villages, calling the value of the advisories into question vis-à-vis other sources of information that inform agricultural decisions in this cluster.
    c. Despite receiving the same advisories with regard to variety selection, the selections of millet and sorghum in this cluster focus on longer cycles than seen in the GLAM villages of cluster 2.
        i. This pattern is consistent with farmers in both clusters using local rain gauges to calibrate their variety selections in relation to the advisories.
    d. It **appears** that the advisories are informing variety selection for those who understand the working of the agrometeorological program.
3) Agricultural strategy:
    a. Different men's agricultural strategies in GLAM villages compared to former GLAM and control villages
        i. In GLAM villages, men's livelihoods are usually heavily market-engaged across the cohorts. This engagement declines across former GLAM and control villages.
        ii. Senior women in GLAM villages are more market-engaged than their former GLAM or control counterparts.
        iii. Junior women in GLAM villages are less market engaged than those in former GLAM and control villages. There is insufficient data to explain this pattern.
        iv. In all cases, there is little evidence to determine whether the observed patterns are is an outcome of advisory use, or a characteristic of these communities that led to their selection as GLAM villages.

b. It is possible that these differences in agricultural and livelihoods strategy are associated with access to and use of the advisories, but definitively establishing this relationship will require further research.

Provisional decision-making model to inform future design

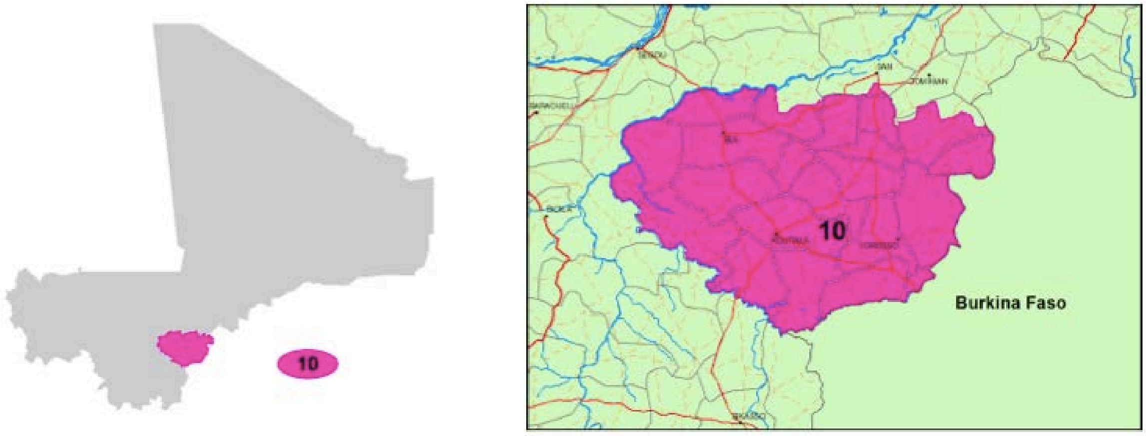
In cluster 3, men and women are agricultural market producers with a heavy livestock husbandry focus. Men control the cultivation of cotton, a unique earning opportunity that also brings with it the challenges inherent in negotiating a bureaucratic system of payments and the fluctuations of wider markets. Where cotton is of declining importance, men are replacing it with other crops that they grow for market sale. Men's identity, therefore, is at least in part bound up in their role as cash croppers.

Women are not confined to subsistence production, but generally stay away from GLAM crops except peanuts. They seem to adopt a strategy that leads with a subsistence focus, and markets surplus production. There are exceptions to this in the cases of particular crops, but these tend to be single crops on farms and gardens holding between five and 10 crops, where the balance of the farm/garden is toward subsistence first. Peanut production is likely tied to wider livelihoods. In this cluster, women's participation in livestock husbandry is very high, suggesting that this is not seen as gendered activity. This is particularly clear when one sees that women are not confined to raising poultry or smaller livestock like goats, but report high rates of cattle and sheep ownership. Livestock ownership and husbandry are not incompatible with a subsistence-first role for women, as these animals most often serve as reserves of wealth to be drawn upon in times of stress or social need. However, livestock husbandry brings with it the need for fodder, and peanut plants can be used for fodder after the peanuts are harvested. This is more likely the case for junior women, who cultivate longer cycles of peanut than do senior women. Senior women cultivate short cycle peanuts, likely attempting to time the harvest for peak prices during the hungry season. This provides more income from peanuts, but makes the storage of the peanut plants impractical as the rains continue, contributing to rot of stored fodder.

Women's high rate of participation in business and trade appears to be linked to the marketing of their garden production, which makes this activity an extension of their agricultural role. Gathering and picking of tree fruits and wild plants is clearly gendered to women, though it is not clear what these women are picking. If they are picking edible fruits, the activity is likely for subsistence. If they are picking/gathering shea, however, they may be selling these fruits at market for income. Given their wider role in this livelihoods system, it seems likely that this activity is principally for subsistence.

This behavioral model suggests that rain-fed GLAM crops, and indeed crops that take most of their value from market sale, are generally viewed as the province of men's production. Women do grow a GLAM crop, but at least some of these women do so to provide both income and food for the household, as well as fodder for their animals. This blurs gender lines in agricultural production somewhat. In a context where women's ownership of livestock is quite common, and women own many of the same animals as men, it is possible that with adequate access to land women could plant more GLAM crops and use the advisories without contravening local social expectations.

# 6.5. CLUSTER 4: ML 10: “SORGHUM, MILLET, AND COTTON”




**Location of the livelihoods zone to which Cluster 4 villages belong. Source: Dixon and Holt, 2010, p.93.**

## 6.5.1. VULNERABILITY CONTEXT

The 13 villages in cluster 4 reach from the southeastern part of Koulikoro Region (very close to the easternmost villages in cluster 3) across northeastern Sikasso and just into southeastern Segou. They largely overlap with FEWS-NET’s mapping of livelihood zone ML10, though some of the more western villages in this cluster extend into FEWS-NET’s ML 11. Rather than contradicting FEWS-NET classifications, this overlap likely represents an uneven transition between these two livelihoods zones that defies easy mapping. According to Dixon and Holt (2010, p.93), annual precipitation in this zone ranges from 700-1000mm, with nearly all precipitation coming in the May-October rainy season. The bulk of this rainfall arrives between June and August. The rain falls on sandy-clay soils that are generally fertile, and enable productive agriculture and the grazing of livestock. The hungry season starts in early June in this zone, and extends until the August harvest of crops. While this is a long hungry season, FEWS-NET refers to this zone as a food surplus area heavily engaged in marketing its crops (Dixon & Holt, 2010, p.93).

According to Dixon and Holt (2010, p.94), cotton is the main cash crop in this zone (except at its northern edges, where it becomes more marginal). However, most crops grown here are marketed, both within Mali and over the border in Burkina Faso. Livestock are principally sold for foreign markets in Burkina Faso, Cote d’Ivoire, and Senegal. These connections present the residents of this region with a wide range of income-generating opportunities. Further, Dixon and Holt (2010, p.93) note that most households in this zone own livestock, so access to these markets is not exclusively the province of the wealthy. However, the use of livestock varies across households. The wealthiest households can use livestock sales as a means of purchasing needed farm supplies and inputs to facilitate their production. Livestock are also critical sources of traction for field preparation, sources of manure for fields, and donkeys serve as sources of transportation that can move manure to fields. The poorest households have relatively few animals, usually mostly poultry, and generally must use them to buy staple foods to get through the hungry season (Dixon & Holt, 2010, p.96). They often prepare their fields by hand, or have to wait until they are lent animals for traction, delaying their planting and likely making it difficult to follow advisories in a timely manner. The challenges facing the poorest households in the hungry season are somewhat mitigated by the gathering of wild foods and tree fruits like shea and néré, which provide both food and income (Dixon & Holt, 2010, pp. 93-94).

Dixon and Holt (2010, p.99-100) capture several challenges facing the residents of this zone. Nearly all of these relate to agricultural production or livestock husbandry. These include pests that attack crops, late payments for cotton by CMDT, timely access to adequate inputs, irregular rainfall, access to adequate water, a lack of pastureland, cattle theft, and malaria (during the rainy season). The listing of Dixon and Holt aggregates the distinct concerns and emphases of different parts of the population of this cluster. The field assessment found that some of these challenges were, in fact, effectively universal (Figure A59). Lack of access to adequate farming equipment was the most regularly reported challenge in this cluster, with everyone mentioning it as an issue and all ranking it among their top three challenges. Irregular or inadequate rainfall was one of the top two or three concerns for everyone in GLAM and control villages. In former GLAM villages, however, only senior men and junior women ranked it as a top challenge, while junior men and senior women did not mention it as a challenge at all. All other challenges were reported less frequently, and usually by specific groups. Seniority seems to be associated with perceptions of lack of access to inputs. Junior men and women ranked this as their first or second concern, while senior men and women ranked this as their fourth or fifth concern. Gender is associated with concerns for changing land cover and soil degradation. Men in GLAM and control villages saw this as a significant challenge (though the men in former GLAM villages did not reference this issue). No women mentioned this challenge. Cattle theft appears to be an issue only in control villages.

| Junior Men | GLAM Average | Former GLAM Average | Control Average |
|---|---|---|---|
| Lack of inputs | 1.5 | 3 | 2.333333333 |
| Irregular/inadequate rainfall | 2 | 1 | 1.166666667 |
| Lack of farming equipment | 2 | 2 | 2 |
| Land cover and soil degradation | 2 | | 1 |
| Low access to land | 3 | | 2.8 |
| Water availability | 3 | | 4 |
| Animal health/vets | 4 | | |
| Lack of animal fodder | 5 | 5 | 3.333333333 |
| Illness | | 4 | |
| Lack of good seeds | | | 2 |
| Market problems | | | 3 |
| Livestock management | | | 4 |
| Cattle Stealing | | | 5 |

| Senior Men | GLAM Average | Former GLAM Average | Control Average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1.333333333 | | 1.333333333 |
| Lack of farming equipment | 2 | 1 | 2 |
| Pests | 2 | 3 | |
| Lack of inputs | 2.5 | 2 | 3 |
| Land cover and soil degradation | 3 | | 2.5 |
| Low access to land | 3.5 | | 4 |
| Water availability | 4 | | 2.5 |
| Market problems | 4 | | 4 |
| Lack of good seeds | | | 1 |
| Food Shortage | | | 1 |
| Cattle Stealing | | | 1 |
| Lack of animal fodder | | | 3 |
| Livestock management | | | 3 |
| Animal health/vets | | | 3.2 |

| Junior Women | GLAM Average | Former GLAM Average | Control Average |
|---|---|---|---|
| Irregular/inadequate rainfall | 1 | | 1 |
| Lack of inputs | 1.666666667 | 1 | 2.6 |
| Lack of farming equipment | 2 | | 1.25 |
| Low access to land | 2 | | 2 |
| Water availability | 2.333333333 | 2 | 2 |
| Lack of good seeds | 3 | | 2.5 |
| Pests | 3 | | 3 |
| Animal health/vets | 3 | | 4 |
| Lack of animal fodder | | 3 | 3 |
| Livestock management | | | 4 |
| Cattle Stealing | | | 4 |

| Senior Women | GLAM Average | Former GLAM Average | Control Average |
|---|---|---|---|
| Irregular/inadequate rainfall | 2 | 1 | 2 |
| Lack of farming equipment | 2.333333333 | 2 | 1.75 |
| Lack of good seeds | 2.5 | 4 | 2 |
| Pests | 3 | | 3 |
| Lack of inputs | 3.333333333 | 3 | 2.5 |
| Animal health/vets | | 5 | 4 |
| Water availability | | | 1 |
| Livestock management | | | 3 |
| Low access to land | | | 3.5 |
| Lack of animal fodder | | | 4 |

**Figure A59: Principal livelihoods challenges, as reported by focus groups in cluster 3.**

### 6.5.2. LIVELIHOODS IN CLUSTER 4

Livelihoods in cluster 4 were structured around agricultural production, with all but six of the 257 respondents indicating they participated in this activity (Figure A60). Livestock husbandry was the second most common activity, but participation varied. Men tended to participate at higher rates than women. Normalized for this gender trend, the lowest rates of participation in livestock husbandry were in GLAM villages, perhaps explaining why they exhibited less concern for fodder than junior men and senior men in control villages. Women dominated trading/business activities, with younger women and women in GLAM villages having the highest rates of participation. Only women in control villages reported participation in wood cutting/firewood collection. Gathering and picking of tree fruits and wild fruits was a woman's activity, with senior women reporting the highest rates of participation (though no women in former GLAM villages report gathering or picking fruits). Senior women in GLAM villages and junior men in former GLAM villages practiced gardening. This odd pattern suggests that this activity was both relatively unimportant to livelihoods in this cluster, and not clearly gendered.

| | GLAM senior man (N=20) | Former GLAM senior man (N=5) | Control Senior Man (N=37) | GLAM Senior Woman (N=18) | Former GLAM senior Woman (N=5) | Control Senior Woman (N=47) | GLAM Junior Man (N=21) | Former GLAM Junior Man (N=4) | Control Junior Man (N=38) | GLAM Junior Woman (N=20) | Former GLAM Junior Woman (N=5) | Control Junior Woman (N=37) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 100.00% | 100.00% | 100.00% | 77.78% | 100.00% | 97.87% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 97.30% |
| Livestock | 65.00% | 80.00% | 81.08% | 27.78% | 80.00% | 51.06% | 66.67% | 100.00% | 65.79% | 45.00% | 80.00% | 56.76% |
| Business | 5.00% | 0.00% | 8.11% | 72.22% | 20.00% | 27.66% | 9.52% | 25.00% | 18.42% | 80.00% | 80.00% | 64.86% |
| Gathering/ picking | 0.00% | 0.00% | 0.00% | 22.22% | 0.00% | 36.17% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 27.03% |
| Gardening | 5.00% | 0.00% | 5.41% | 27.78% | 0.00% | 4.26% | 0.00% | 25.00% | 0.00% | 10.00% | 0.00% | 2.70% |
| Other | 10.00% | 0.00% | 0.00% | 0.00% | 0.00% | 25.53% | 19.05% | 0.00% | 10.53% | 0.00% | 0.00% | 13.51% |
| Logging | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 31.91% | 0.00% | 0.00% | 0.00% | 20.00% | 0.00% | 10.81% |
| Handicrafts | 5.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 14.29% | 25.00% | 5.26% | 0.00% | 0.00% | 0.00% |

**Figure A60: Livelihoods activities in cluster 3.**

### 6.5.3. AGRICULTURE IN CLUSTER 4

| | GLAM senior man | Former GLAM senior man | Control Senior Man | GLAM Senior Woman | Former GLAM senior Woman | Control Senior Woman | GLAM Junior Man | Former GLAM Junior Man | Control Junior Man | GLAM Junior Woman | Former GLAM Junior Woman | Control Junior Woman |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg # crops | 4.3 | 5.2 | 5.2 | 2.9 | 2.0 | 3.4 | 5.1 | 6.8 | 5.3 | 2.8 | 3.0 | 2.9 |
| Peanut | 45.00% | 20.00% | 72.97% | 71.43% | 100.00% | 83.78% | 61.90% | 75.00% | 73.68% | 80.00% | 100.00% | 56.76% |
| Banana | 0.00% | 0.00% | 0.00% | 7.14% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Cabbage | 0.00% | 0.00% | 0.00% | 7.14% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Cucumber | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.70% |
| Cotton | 80.00% | 100.00% | 97.30% | 0.00% | 0.00% | 5.41% | 85.71% | 100.00% | 94.74% | 0.00% | 0.00% | 8.11% |
| Fonio | 10.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.70% | 14.29% | 0.00% | 0.00% | 0.00% | 40.00% | 0.00% |
| Okra | 0.00% | 0.00% | 0.00% | 14.29% | 0.00% | 32.43% | 4.76% | 25.00% | 0.00% | 45.00% | 40.00% | 56.76% |
| Henna | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.70% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Lettuce | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.70% | 0.00% | 0.00% | 0.00% | 10.00% | 0.00% | 5.41% |
| Maize | 80.00% | 100.00% | 100.00% | 7.14% | 0.00% | 16.22% | 95.24% | 100.00% | 97.37% | 5.00% | 0.00% | 8.11% |
| Millet | 75.00% | 60.00% | 89.19% | 14.29% | 0.00% | 13.51% | 95.24% | 75.00% | 78.95% | 20.00% | 0.00% | 2.70% |
| Cowpeas | 15.00% | 100.00% | 35.14% | 14.29% | 0.00% | 29.73% | 33.33% | 75.00% | 42.11% | 35.00% | 0.00% | 24.32% |
| Onion | 0.00% | 0.00% | 0.00% | 21.43% | 0.00% | 2.70% | 0.00% | 0.00% | 0.00% | 25.00% | 0.00% | 21.62% |
| Hibiscus | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 10.81% | 0.00% | 0.00% | 0.00% | 5.00% | 0.00% | 8.11% |
| Papaya | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.70% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Watermelon | 0.00% | 0.00% | 2.70% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 2.63% | 0.00% | 0.00% | 0.00% |
| Sweet potato | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 50.00% | 5.26% | 0.00% | 0.00% | 0.00% |
| Chili pepper | 0.00% | 0.00% | 2.70% | 14.29% | 0.00% | 5.41% | 0.00% | 0.00% | 2.63% | 5.00% | 0.00% | 13.51% |
| Rice | 25.00% | 0.00% | 5.41% | 28.57% | 100.00% | 43.24% | 28.57% | 0.00% | 18.42% | 20.00% | 100.00% | 27.03% |
| Roselle | 0.00% | 20.00% | 0.00% | 0.00% | 0.00% | 5.41% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Sesame | 0.00% | 20.00% | 0.00% | 7.14% | 0.00% | 8.11% | 0.00% | 25.00% | 0.00% | 5.00% | 0.00% | 2.70% |
| Soy | 0.00% | 0.00% | 10.81% | 0.00% | 0.00% | 13.51% | 0.00% | 0.00% | 13.16% | 0.00% | 0.00% | 10.81% |
| Sorghum | 100.00% | 100.00% | 94.59% | 57.14% | 0.00% | 54.05% | 95.24% | 100.00% | 97.37% | 10.00% | 0.00% | 18.92% |
| Tobacco | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 5.41% |
| Tomato | 0.00% | 0.00% | 0.00% | 28.57% | 0.00% | 5.41% | 0.00% | 0.00% | 0.00% | 10.00% | 20.00% | 10.81% |
| Bambara nuts | 0.00% | 0.00% | 8.11% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 8.11% |

| | |
|---|---|
| Onion | Women's crop |
| Rice | Men's crop |
| Sorghum | Crop targeted by the agromet program |

**Table A4: All crops grown in cluster 4, by subgroup and GLAM/former GLAM/control village.**

Farmers in cluster 4 raised 26 crops (Table A4). Three crops (cotton, watermelon, and sweet potatoes) were exclusively men's crops, while men also dominated the cultivation of maize and millet. Thus, three of the five crops targeted by agrometeorological advisories were largely confined to men's fields. Ten crops were women's crops, and none of these were targeted by the agrometeorological program. Men's near-exclusive control over three of the five crops for which there were agrometeorological advisories suggests that their agricultural production benefitted disproportionately from the program.

Senior Men

In cluster 4, 45% (n=9) of senior men in GLAM villages reported using the advisories to inform their agricultural decisions. All of these men demonstrated a working knowledge of the advisories.

Senior men in GLAM villages raised an average of 4.3 crops, less than the 5.2 crops of former GLAM villages and the 5.2 crops in control villages. Figure A61 compares the crop selection preferences of senior men in this cluster across GLAM, former GLAM, and control villages. As the figure shows, there was little difference between these selections, except for a slightly greater emphasis on cowpeas in former GLAM villages. Senior men in control villages grew peanuts at significantly higher rates than in GLAM or former GLAM villages.

**GLAM senior man**

| | |
|---|---|
| Avg # crops | 4.3 |
| Sorghum | 100.00% |
| Maize | 80.00% |
| Cotton | 80.00% |
| Millet | 75.00% |
| Peanut | 45.00% |
| Rice | 25.00% |
| Cowpeas | 15.00% |
| Fonio | 10.00% |

**Former GLAM senior man**

| | |
|---|---|
| Avg # crops | 5.2 |
| Sorghum | 100.00% |
| Maize | 100.00% |
| Cotton | 100.00% |
| Cowpeas | 100.00% |
| Millet | 60.00% |
| Peanut | 20.00% |
| Roselle | 20.00% |
| Sesame | 20.00% |

**Control Senior Man**

| | |
|---|---|
| Avg # crops | 5.2 |
| Maize | 100.00% |
| Cotton | 97.30% |
| Sorghum | 94.59% |
| Millet | 89.19% |
| Peanut | 72.97% |
| Cowpeas | 35.14% |
| Soy | 10.81% |
| Bambara nuts | 8.11% |
| Rice | 5.41% |
| Watermelon | 2.70% |
| Chili pepper | 2.70% |

**Figure A61: The crop selection preferences of senior men in cluster 4.**

Figure A62 demonstrates there was little difference in the crop selections of those using the advisories and senior men in GLAM villages at large.

**GLAM senior man: All**

| | |
|---|---|
| Avg # crops | 4.3 |
| Sorghum | 100.00% |
| Maize | 80.00% |
| Cotton | 80.00% |
| Millet | 75.00% |
| Peanut | 45.00% |
| Rice | 25.00% |
| Cowpeas | 15.00% |
| Fonio | 10.00% |

**GLAM Senior Man: Definite**

| | |
|---|---|
| Avg # crops | 4.166667 |
| Sorghum | 100.00% |
| Cotton | 83.33% |
| Maize | 83.33% |
| Millet | 66.67% |
| Peanuts | 41.67% |
| Rice | 33.33% |
| Cowpeas | 8.33% |

**Figure A62: The crop selections of senior men in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

The patterns of variety selection in Figure A63 did not suggest any major differences between those receiving the advisories and those who are not. In general, senior men in GLAM and control communities distributed their varieties across a broad range of cycles for most crops, while in former GLAM villages the focus was on one or two varieties at most (though these varieties were often in the middle of the cycle distribution seen in GLAM and control villages). With the exception of peanuts, the selections of senior men in GLAM villages conform with the advisories, with the distribution of variety selection across sorghum and millet likely a reflection of a dry second dekad in May, followed by a wet third decade. Depending on their specific location, some farmers may have received adequate rainfall to follow advisory suggestions for millet and sorghum at the end of May, while others may have had to wait into June, forcing them into shorter cycles. Peanut variety selections by senior men in GLAM villages were much shorter-cycle than recommended by the advisories, which might reflect their status as a crop grown at least in part for sale. It is possible that these men were trying to time their harvest for peak prices in the hungry season, and therefore were disregarding the advisories. With few exceptions farmers who planted GLAM crops planted only a single variety. Therefore at the individual and household level, those following the advisories are focusing on a single cycle length, which does not necessarily lead to a more resilient overall agricultural strategy.

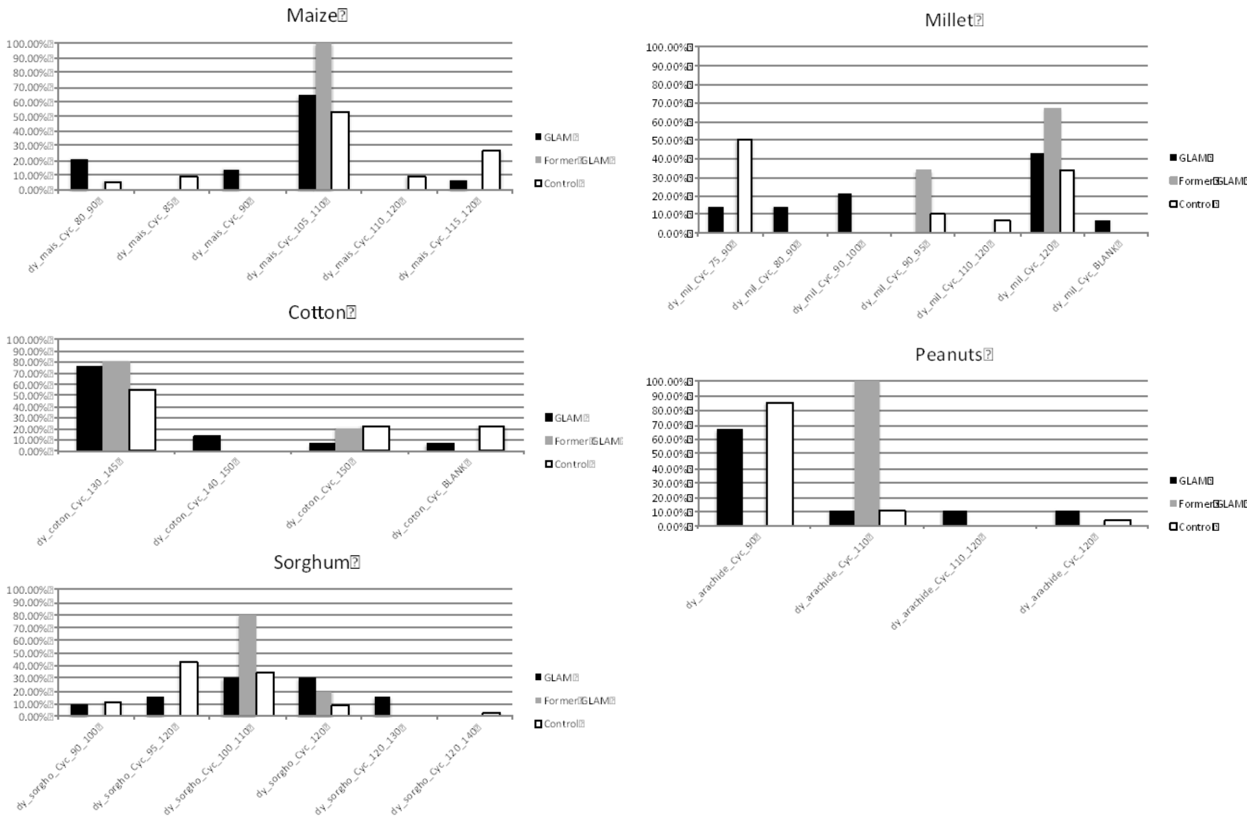



**Figure A63: Variety selections across the five agrometeorological program crops in cluster 4.**

Figure A64 illustrates the very similar patterns of variety selection among those using the advisories, and senior men in GLAM villages in general.

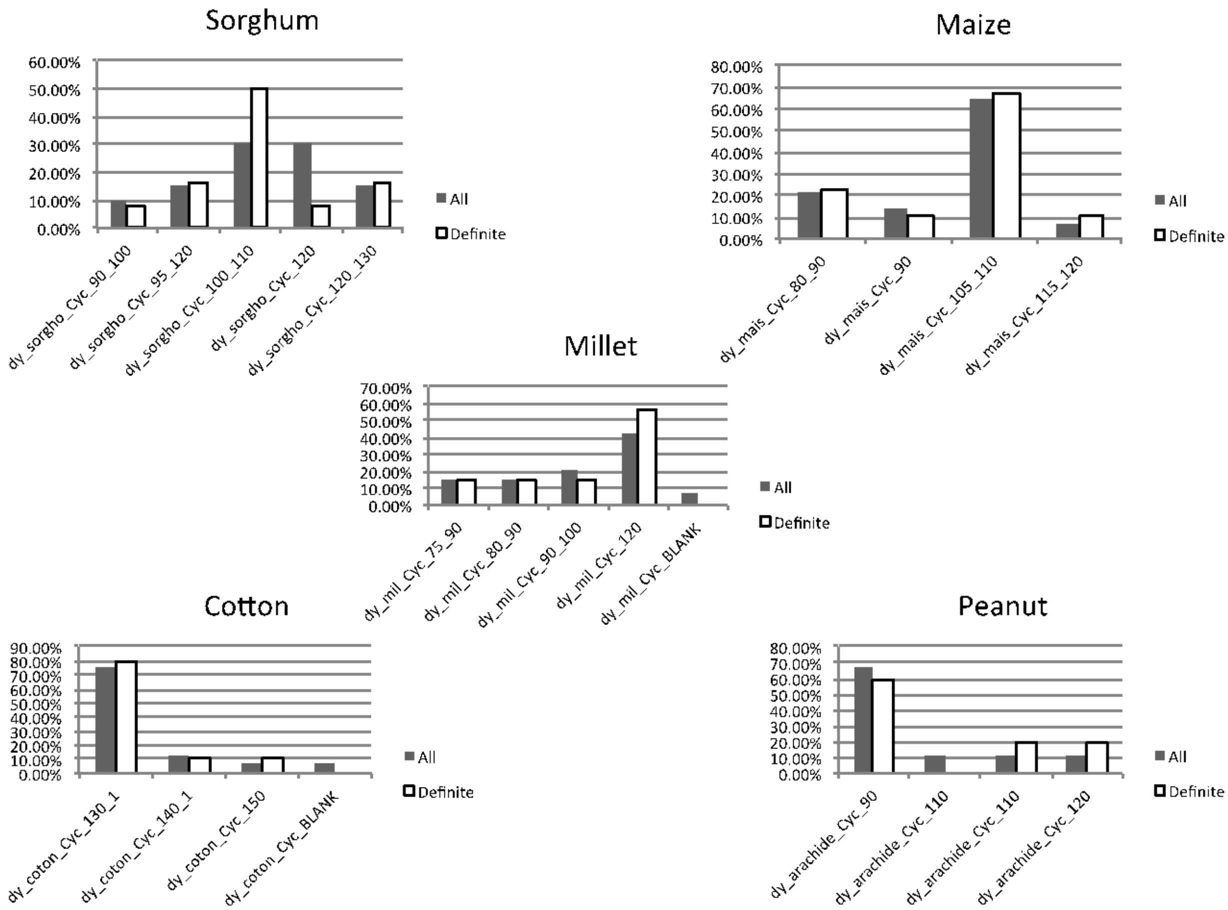



**Figure A64: Comparisons of variety selection among senior men in GLAM villages, comparing all such men and those that used the advisories and accurately reported the workings of the program.**

Figure A65 illustrates the uses to which senior men put their crops in GLAM, former GLAM, and control villages. This figure reinforces the notion that there was little to separate the agricultural strategies of senior men, whether they are engaged by the advisories or not. These men viewed their crops as having more or less the same uses, and planted them with more or less the same frequencies. In all cases, these men produced cotton as the core of their livelihoods, and sold that crop. Around it they raised maize and millet for household consumption, and sorghum for fodder and household consumption. This is a strategy that mixed market engagement with a strong subsistence-cropping hedge against market shifts and late payments. None of these men appeared to expect much by way of marketable surpluses of staple crops (with the exception of peanuts), and perhaps were not seeking such a surplus as they could rely on cotton sales for their cash income needs.

**GLAM senior man**

| | |
|---|---|
| Sorghum | Eat all |
| Maize | Eat all |
| Cotton | Sell all |
| Millet | Eat all |
| Peanut | Eat more than sell |
| Rice | Eat and sell equally |
| Cowpeas | Eat all |
| Fonio | Eat all |

**Former GLAM senior man**

| | |
|---|---|
| Sorghum | Eat all |
| Maize | Eat all |
| Cotton | Sell all |
| Cowpeas | Eat all |
| Millet | Eat all |

**Control Senior Man**

| | |
|---|---|
| Maize | Eat all |
| Cotton | Sell all |
| Sorghum | Eat all |
| Millet | Eat all |
| Peanut | Eat more than sell |
| Cowpeas | Eat more than sell |
| Soy | Sell more than eat |
| Bambara nuts | Eat all |
| Rice | Eat more than sell |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A65: Intended uses of all crops on two or more senior men's farms, in GLAM, former GLAM, and control villages, for cluster 4.**

There were almost no differences between the wider livelihoods structures of senior men across the three village types, which perhaps explains the near uniformity of agricultural strategy in this cluster. Among senior men, there was little evidence that the agrometeorological advisories are impacting their decision-making.

<u>Junior men</u>

Eighty-one percent (n=17) of junior men in GLAM villages reported using the advisories. Of these, 71% (n=12) demonstrated a working understanding of the program and advisories.

In cluster 4, junior men in GLAM villages grew an average of 5.1 crops, significantly less than the 6.8 crops grown in former GLAM villages, but similar to the 5.3 crops in control villages. Figure A66 illustrates the crop selection preferences of junior men in the three village types. There was no evidence to suggest that junior men's crop selection is at all variable across the three village types, and therefore there was no evidence that access to the advisories affected this decision.

**GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 5.1 |
| Maize | 95.24% |
| Sorghum | 95.24% |
| Millet | 95.24% |
| Cotton | 85.71% |
| Peanut | 61.90% |
| Cowpeas | 33.33% |
| Rice | 28.57% |
| Fonio | 14.29% |
| Okra | 4.76% |

**Former GLAM Junior Man**

| | |
|---|---|
| Avg # crops | 6.8 |
| Maize | 100.00% |
| Sorghum | 100.00% |
| Cotton | 100.00% |
| Millet | 75.00% |
| Peanut | 75.00% |
| Cowpeas | 75.00% |
| Sweet potato | 50.00% |
| Okra | 25.00% |
| Sesame | 25.00% |

**Control Junior Man**

| | |
|---|---|
| Avg # crops | 5.3 |
| Maize | 97.37% |
| Sorghum | 97.37% |
| Cotton | 94.74% |
| Millet | 78.95% |
| Peanut | 73.68% |
| Cowpeas | 42.11% |
| Rice | 18.42% |
| Soy | 13.16% |
| Sweet potato | 5.26% |
| Watermelon | 2.63% |
| Chili pepper | 2.63% |

**Figure A66: The crop selection preferences of junior men in cluster 4, with comparisons between GLAM, former GLAM, and control villages.**

Figure A67 demonstrates that there was very little difference in crop selection among those claiming to use the advisories, those using the advisories, and junior men in GLAM villages on the whole.

**GLAM Junior Man: All**

| | |
|---|---|
| Avg # crops | 5.1 |
| Maize | 95.24% |
| Sorghum | 95.24% |
| Millet | 95.24% |
| Cotton | 85.71% |
| Peanut | 61.90% |
| Cowpeas | 33.33% |
| Rice | 28.57% |
| Fonio | 14.29% |
| Okra | 4.76% |

**GLAM Junior Man: Probable**

| | |
|---|---|
| Avg # crops | 5.2 |
| Millet | 100.00% |
| Maize | 94.44% |
| Sorghum | 94.44% |
| Cotton | 88.89% |
| Peanut | 61.11% |
| Rice | 33.33% |
| Cowpeas | 27.78% |
| Fonio | 16.67% |
| Okra | 5.56% |

**GLAM Junior Man: Definite**

| | |
|---|---|
| Avg # crops | 5.416667 |
| Cotton | 100.00% |
| Maize | 100.00% |
| Sorghum | 100.00% |
| Millet | 100.00% |
| Peanuts | 66.67% |
| Rice | 25.00% |
| Cowpeas | 25.00% |
| Fonio | 8.33% |
| Okra | 8.33% |

**Figure A67: The crop selections of junior men in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

The patterns of variety selection in Figure A68 suggest that junior men in GLAM villages might have used advisories to inform their variety selection. Their variety selections conformed to the advisories for all crops except peanuts. The range of varieties of millet and sorghum seen in the farms of GLAM junior men in this cluster is explained by the pattern of dry/wet/dry precipitation totals across the three decades of May, which likely led some farmers to wait to plant their millet and sorghum while others were able to plant sooner. These men were focused on shorter-cycle peanut varieties than their former GLAM counterparts, likely reflecting an effort to gain an early harvest and therefore time markets for maximum prices during the hungry season. Nearly all junior men were selecting a single variety to plant on their farms, thus reducing their resilience to shocks and uncertainty.

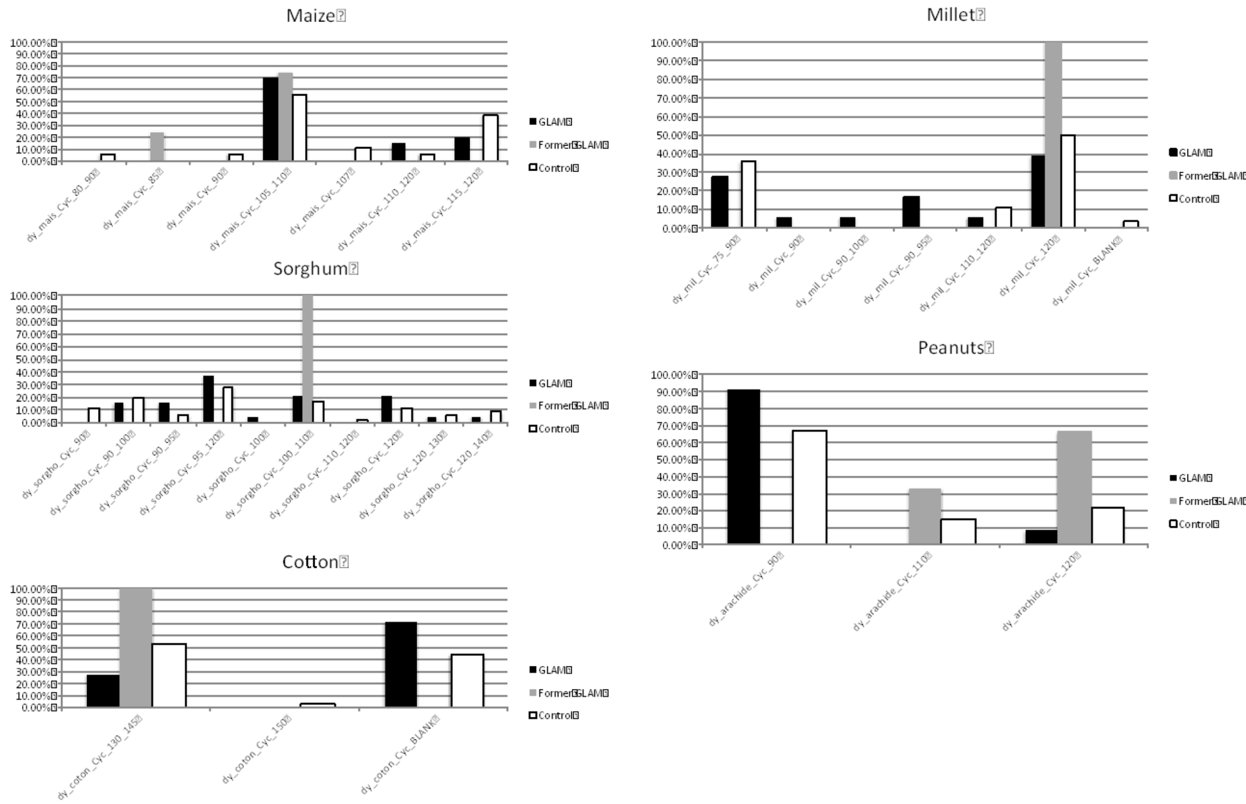



**Figure A68: Variety selections across the five agrometeorological program crops in cluster 4.**

Figure A69 demonstrates that there was little difference between the variety selections of those using the advisories, those who claimed to use the advisories, and junior men in GLAM villages in general, though those using the advisories adhere most closely to the advisory-recommended cycle lengths in their selections.

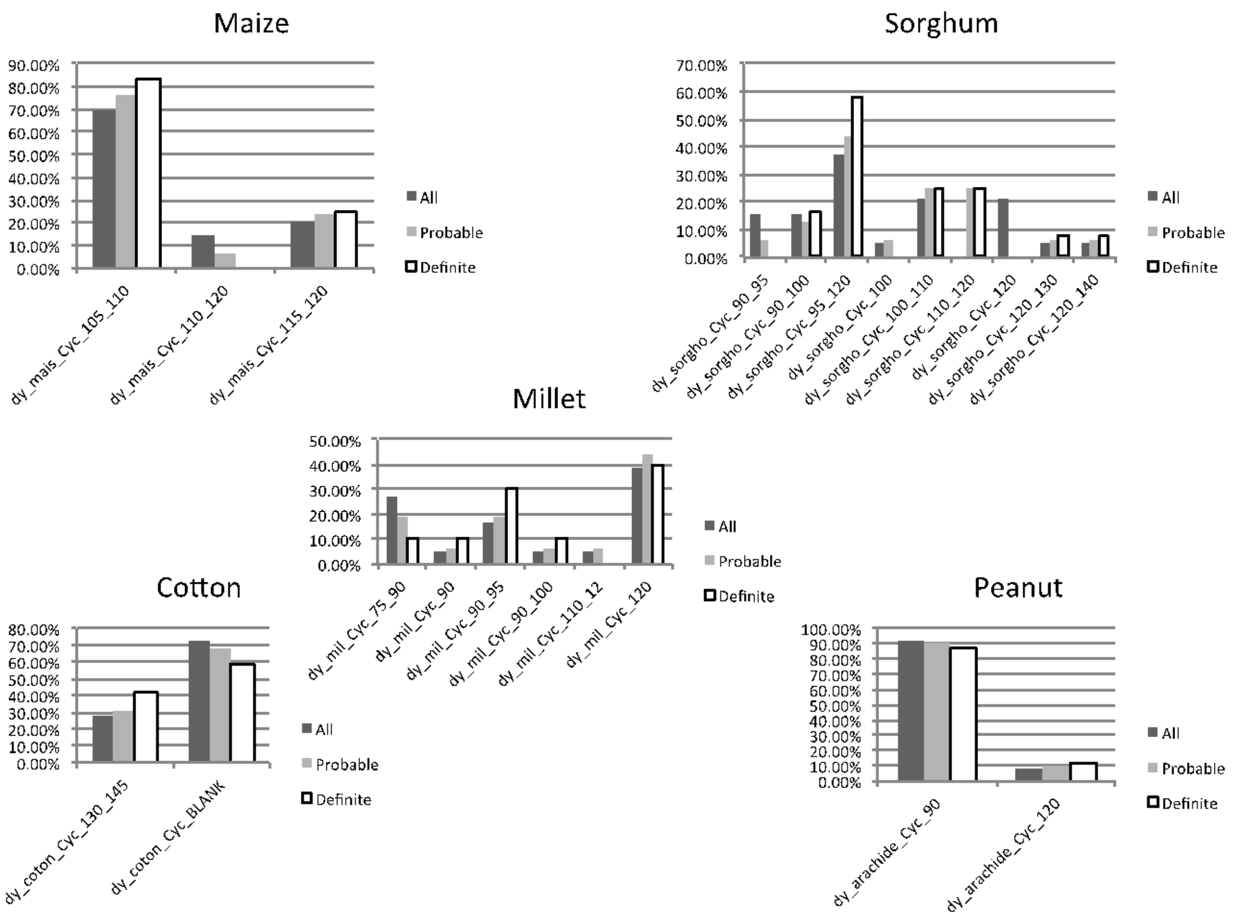



**Figure A69: Comparisons of variety selection among junior men in GLAM villages, comparing all such men, those that claimed to be using the advisories, and those that used the advisories and accurately reported the workings of the program.**

Figure A70 illustrates the uses to which junior men in GLAM, former GLAM, and control villages put their crops. This figure demonstrates that there was little, if any, difference in agricultural strategy among junior men across these village types. It is interesting to note that these men were somewhat more market oriented than senior men in this cluster, and expected to generate marketable surpluses of all or nearly all of their crops. This difference between senior and junior men, along with the fact that, as a rule, junior men had to clear any shifts in agricultural strategy with senior men in their families, suggests that senior men's strategies, which emphasize the production of staple crops for subsistence, were not fundamentally different from those of junior men, but instead reflected their diminished capacity for extensive agricultural labor needed to generate such a surplus.  There is little, however, to suggest that among junior men the agrometeorological advisories were informing crop selection or agricultural strategy.

**GLAM Junior Man**

| | |
|---|---|
| Maize | Eat more than sell |
| Sorghum | Eat more than sell |
| Millet | Eat more than sell |
| Cotton | Sell all |
| Peanut | Eat and sell equally |
| Cowpeas | Eat more than sell |
| Rice | Eat more than sell |
| Fonio | Sell more than eat |

**Former GLAM Junior Man**

| | |
|---|---|
| Maize | Eat more than sell |
| Sorghum | Eat more than sell |
| Cotton | Sell all |
| Millet | Eat more than sell |
| Peanut | Eat more than sell |
| Cowpeas | Sell more than eat |
| Sweet potato | Sell more than eat |

**Control Junior Man**

| | |
|---|---|
| Maize | Eat more than sell |
| Sorghum | Eat more than sell |
| Cotton | Sell all |
| Millet | Eat more than sell |
| Peanut | Eat more than sell |
| Cowpeas | Eat more than sell |
| Rice | Eat all |
| Soy | Eat more than sell |
| Sweet potato | Eat and sell equally |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A70: Intended uses of all crops on two or more junior men's farms, in GLAM, former GLAM, and control villages, for cluster 4.**

In summary, because the junior men of this cluster had broadly similar livelihoods structures and very similar crop selection and crop use decisions, differences in cotton and perhaps peanut variety selections are not easily explained, and therefore might indicate that the advisories are impacting the agricultural decisions of junior men in the GLAM villages.

<u>Senior women</u>

In this cluster, 11% (n=2) of senior women reported using the advisories, but neither woman demonstrated a functional understanding of the program, making it unlikely they were using the advisories. As in other clusters, this program may have affected their agricultural practices, but likely through the seed purchases and agricultural decisions of their husbands and sons. It is important to note that five senior women (28%) argued that the advisories and program were for men only, suggesting a strongly gendered component to its use in this cluster.

In cluster 4, senior women in GLAM villages grew an average of 2.9 crops, slightly more than the 2.0 crops former GLAM villages, and slightly less than the 3.4 crops in control villages (Figure A71). There was little difference in crop selection between GLAM and control villages, with similar rates of cultivation for peanuts and sorghum. In both GLAM and control villages, these core rain-fed cereals were then complemented with one or two other crops. It is difficult to interpret the data from the former GLAM village, where senior women only reported growing two crops, peanuts and rice. Every senior women in this village reported growing these crops.

**GLAM Senior Woman**

| | |
|---|---|
| Avg # crops | 2.9 |
| Peanut | 71.43% |
| Sorghum | 57.14% |
| Rice | 28.57% |
| Tomato | 28.57% |
| Onion | 21.43% |
| Okra | 14.29% |
| Cowpeas | 14.29% |
| Millet | 14.29% |
| Chili pepper | 14.29% |
| Maize | 7.14% |
| Sesame | 7.14% |
| Banana | 7.14% |
| Cabbage | 7.14% |

**Former GLAM senior Woman**

| | |
|---|---|
| Avg # crops | 2.0 |
| Peanut | 100.00% |
| Rice | 100.00% |

**Control Senior Woman**

| | |
|---|---|
| Avg # crops | 3.4 |
| Peanut | 83.78% |
| Sorghum | 54.05% |
| Rice | 43.24% |
| Okra | 32.43% |
| Cowpeas | 29.73% |
| Maize | 16.22% |
| Millet | 13.51% |
| Soy | 13.51% |
| Hibiscus | 10.81% |
| Sesame | 8.11% |
| Tomato | 5.41% |
| Chili pepper | 5.41% |
| Cotton | 5.41% |
| Roselle | 5.41% |
| Onion | 2.70% |
| Fonio | 2.70% |
| Henna | 2.70% |
| Lettuce | 2.70% |
| Papaya | 2.70% |

**Figure A71: The crop selection preferences of senior women in cluster 4.**

Variety selection among senior women suggests that there was some emphasis on the selection of shorter cycle peanut, sorghum, and maize varieties in GLAM villages than in control villages (Figure A72). GLAM and former GLAM villages had very similar patterns of selection at the community level. The variety selections of senior women in GLAM villages were similar to those of senior men in their villages, and somewhat similar to junior men, suggesting that they were influenced by the variety selections and purchases of their husbands or sons. Virtually all senior women, GLAM or otherwise, were planting only a single variety of a given GLAM crop, making their individual and household production vulnerable to climate variability.

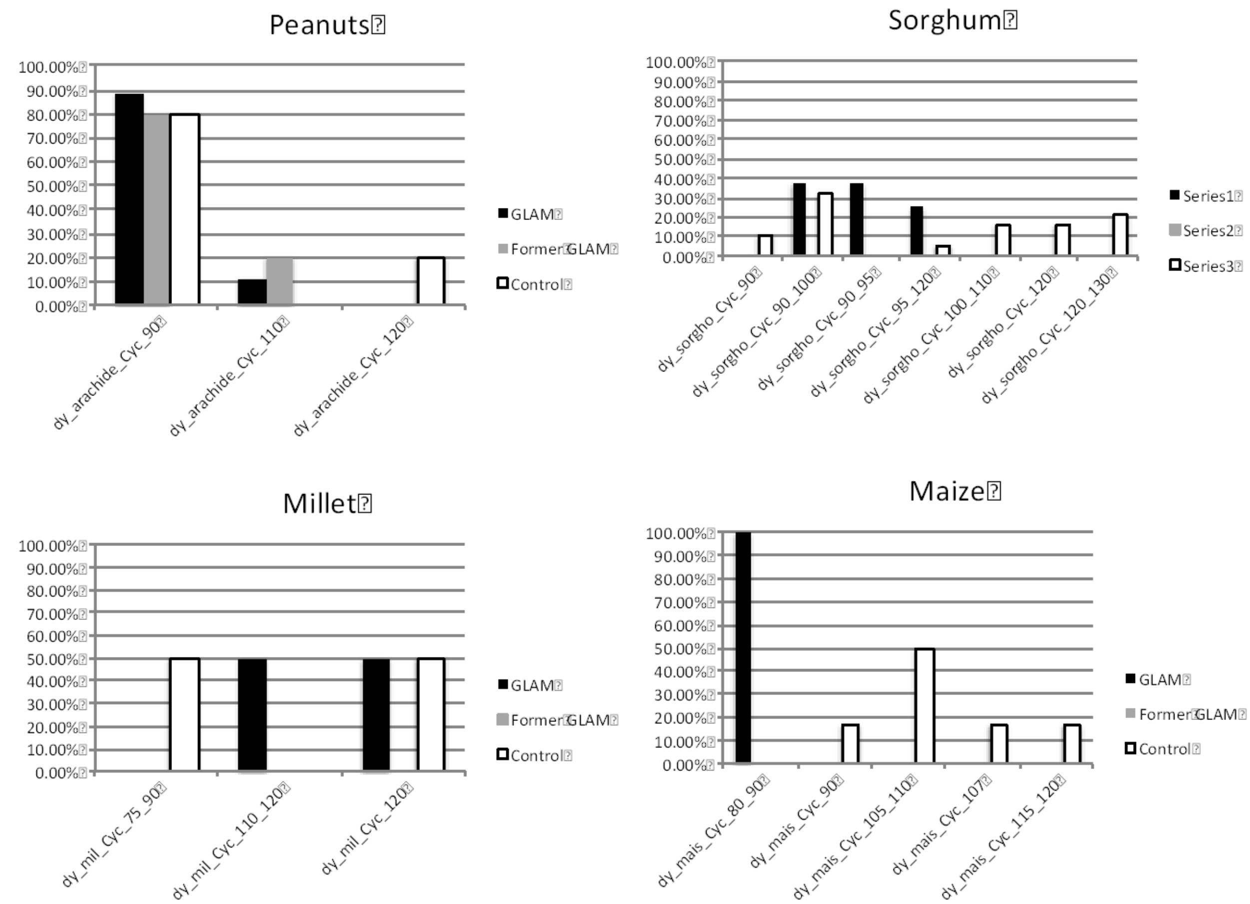



**Figure A72: Variety selections across the four agrometeorological program crops in cluster 4 for which there were differences among senior women.**

Figure A73 illustrates the uses that senior women put their crops to in each of the three village types. When compared to control villages, senior women in GLAM villages were somewhat more market-oriented in their production. In GLAM villages senior women expected a marketable surplus of nearly every crop. In control villages, senior women were clearly hedging the cultivation of crops for which they have an expectation of surplus with crops that they only intended for subsistence production. Only a few crops grown by senior women in this cluster are primarily intended for market sale, and these were cultivated relatively infrequently. The strategy of women in the former GLAM village is difficult to interpret. It appears they had a completely hedged strategy, focusing on peanuts for market sale and rice for subsistence. It is clear that these women viewed peanuts differently than do the senior women in GLAM or control households, but this does not seem to bear any relation to agrometeorological advisories. Senior women in former GLAM villages appear to operate under an agricultural strategy that produces both cash income and subsistence food in similar amounts. The heavy market focus in their peanut production was different than that seen in either GLAM or control villages.

**GLAM Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Sorghum | Eat more than sell |
| Tomato | Sell more than eat |
| Rice | Eat more than sell |
| Onion | Sell more than eat |
| Chili peppers | Eat and sell equally |
| Okra | Eat more than sell |
| Cowpeas | Eat more than sell |
| Millet | Eat all |

**Former GLAM Senior Woman**

| | |
|---|---|
| Peanut | Sell more than eat |
| Rice | Eat all |

**Control Senior Woman**

| | |
|---|---|
| Peanut | Eat more than sell |
| Sorghum | Eat all |
| Rice | Eat all |
| Okra | Eat more than sell |
| Cowpeas | Eat all |
| Maize | Eat and sell equally |
| Soy | Sell more than eat |
| Millet | Eat more than sell |
| Hibiscus | Eat all |
| Sesame | Sell all |
| Chili pepper | Sell all |
| Cotton | Sell all |
| Tomato | Sell more than eat |
| Roselle | Eat all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A73: Intended uses of all crops on two or more senior women's farms for cluster 4.**

In cluster 4, senior women operated under broadly similar agricultural strategies across village types, with a general focus on growing subsistence crops, and marketing any surplus production. The odd agricultural pattern of senior women in former GLAM villages is explained by their heavy animal ownership. 80% of these women reported raising livestock as part of their livelihoods, while only 27% of those in GLAM villages and 51% of those in control villages owned livestock. This suggests that these women had a completely different livelihoods structure than that in the other two village types. These women reported a great disparity in gardening, with 72% of those in GLAM villages reporting this activity, versus only 20% in former GLAM villages and 27% in control villages. It is difficult to rectify this reporting with the average number and range of crops reported in both GLAM and control villages, but if it is true, the greater emphasis on gardening might explain GLAM senior women's somewhat greater emphasis on market engagement with their agricultural production. In any case, the relationships between men's and women's variety selections suggests that differences in variety selection between senior women in GLAM villages and their control and former GLAM counterparts was likely driven by men's decision-making, and not by the direct use of advisories.

Junior women

In this cluster, 25% (n=5) of junior women claimed to use the advisories. All five women demonstrated a functional understanding of the program, suggesting they are engaged with the advisories. However, 30% (n=6) women argued that the program was only for men, suggesting that junior women's engagement with the program is fraught, and may be contested along gender lines.

In cluster 4, junior women in GLAM villages raised an average of 2.8 crops, a number very similar to the 3 crops in former GLAM villages and the 2.9 crops in control villages (Figure A74). Junior women in GLAM and former GLAM villages grew peanuts at a significantly higher rate than in control villages. However, peanuts were the most popular crop in all three village types, so it is difficult to say if this difference in crop selection relates meaningfully to agricultural strategy or access to advisories. Broadly speaking, junior women in this cluster distributed their production across a range of crops. While each individual woman raised two or three crops, they chose from between 13 (GLAM villages) and 18 (control villages) crops. It is worth noting, however, that quite a bit of junior women's production is focused on hand-irrigated garden crops. Eighty percent of junior women in GLAM and former GLAM villages, and 64% of junior women in control villages, reported participating in gardening. In the former GLAM village, rice was very popular, much more so than in either GLAM or control villages.

**GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 2.8 |
| Peanut | 80.00% |
| Okra | 45.00% |
| Cowpeas | 35.00% |
| Onion | 25.00% |
| Rice | 20.00% |
| Millet | 20.00% |
| Tomato | 10.00% |
| Sorghum | 10.00% |
| Lettuce | 10.00% |
| Chili pepper | 5.00% |
| Maize | 5.00% |
| Hibiscus | 5.00% |
| Sesame | 5.00% |

**Former GLAM Junior Woman**

| | |
|---|---|
| Avg # crops | 3.0 |
| Peanut | 100.00% |
| Rice | 100.00% |
| Okra | 40.00% |
| Fonio | 40.00% |
| Tomato | 20.00% |

**Control Junior Woman**

| | |
|---|---|
| Avg # crops | 2.9 |
| Peanut | 56.76% |
| Okra | 56.76% |
| Rice | 27.03% |
| Cowpeas | 24.32% |
| Onion | 21.62% |
| Sorghum | 18.92% |
| Chili pepper | 13.51% |
| Tomato | 10.81% |
| Soy | 10.81% |
| Maize | 8.11% |
| Hibiscus | 8.11% |
| Cotton | 8.11% |
| Bambara nuts | 8.11% |
| Lettuce | 5.41% |
| Tobacco | 5.41% |
| Millet | 2.70% |
| Sesame | 2.70% |
| Cucumber | 2.70% |

**Figure A74: The crop selection preferences of junior women in cluster 4.**

Figure A75 suggests that those women who are using the advisories planted GLAM crops at slightly higher rates than junior women in GLAM villages on the whole. This may reflect greater confidence in these crops because of the advisories, though this is impossible to determine with confidence from the data at hand.

**GLAM Junior Woman: All**

| | |
|---|---|
| Avg # crops | 2.8 |
| Peanut | 80.00% |
| Okra | 45.00% |
| Cowpeas | 35.00% |
| Onion | 25.00% |
| Rice | 20.00% |
| Millet | 20.00% |
| Tomato | 10.00% |
| Sorghum | 10.00% |
| Lettuce | 10.00% |
| Chili pepper | 5.00% |
| Maize | 5.00% |
| Hibiscus | 5.00% |
| Sesame | 5.00% |

**GLAM Junior Woman: Definite**

| | |
|---|---|
| Avg # crops | 4.3 |
| Peanuts | 83.33% |
| Cowpeas | 66.67% |
| Millet | 50.00% |
| Onion | 50.00% |
| Okra | 33.33% |
| Lettuce | 33.33% |
| Sorghum | 33.33% |
| Tomato | 33.33% |
| Maize | 16.67% |
| Bell Pepper | 16.67% |
| Rice | 16.67% |

**Figure A75: The crop selections of junior men in GLAM villages, by all and those that claim to use advisories and understand how the program works.**

The variety selections of junior women present a mixed pattern (Figure A76). It appears that junior women in GLAM villages selected shorter cycles of peanuts than those in former GLAM villages, a pattern seen on both senior and junior men's farms. This pattern is likely a product of either a reliance on husbands and/or sons for seeds, or women's individual desires to time markets for maximum pricing during the hungry season. These women planted advisory-recommended varieties of millet and maize, but much shorter-cycle varieties of sorghum. The number of women raising these crops was very small, and therefore this pattern is difficult to rigorously interpret. In any case, at the individual level these women focused on a single variety of each GLAM crop, making their personal farms vulnerable to seasonal variability.

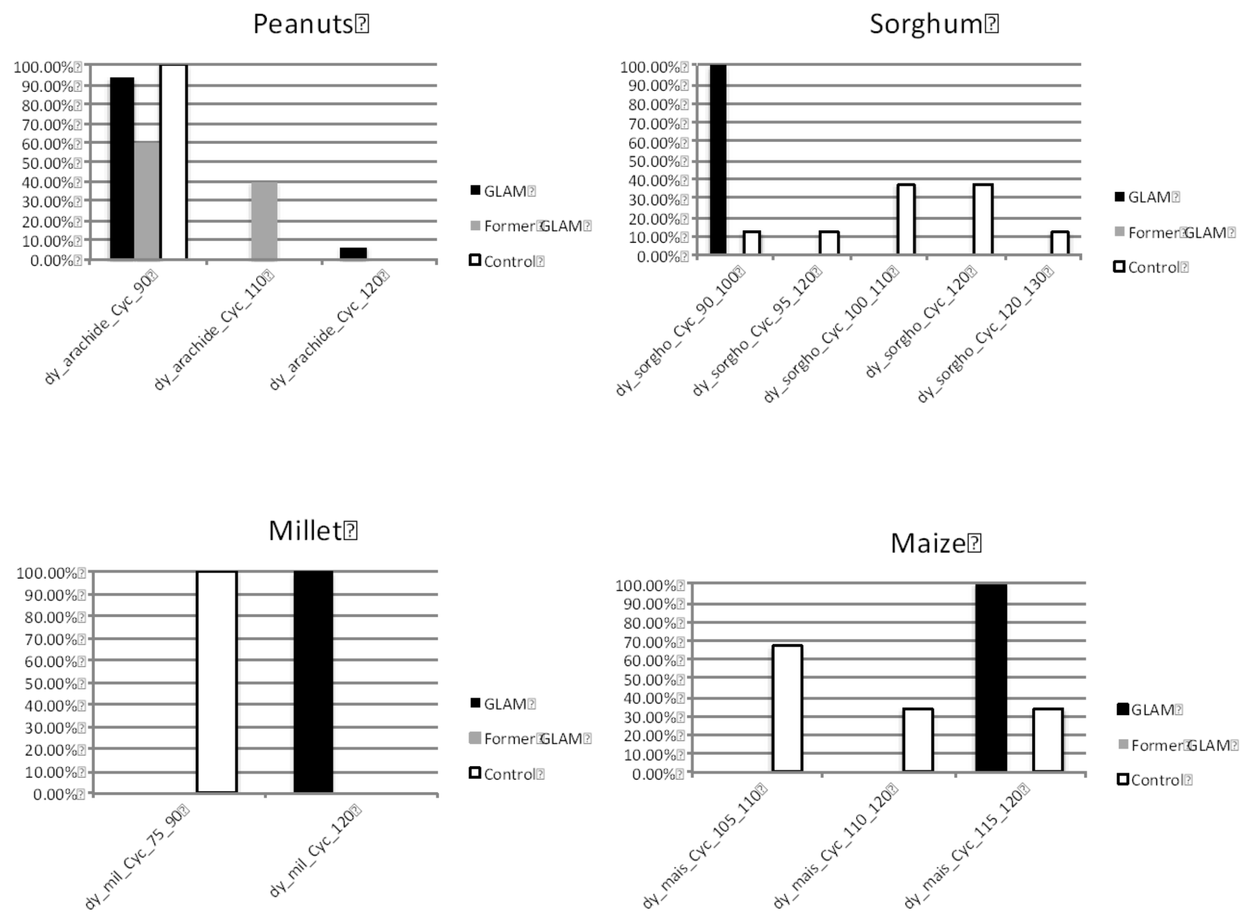



**Figure A76: Comparisons of variety selection among senior men in GLAM villages, comparing all such men and those that used the advisories and accurately reported the workings of the program.**

Figure A77 shows that for the one crop where junior women in GLAM villages split their variety selections, the difference was very small and unlikely to reflect any impact of the advisories.

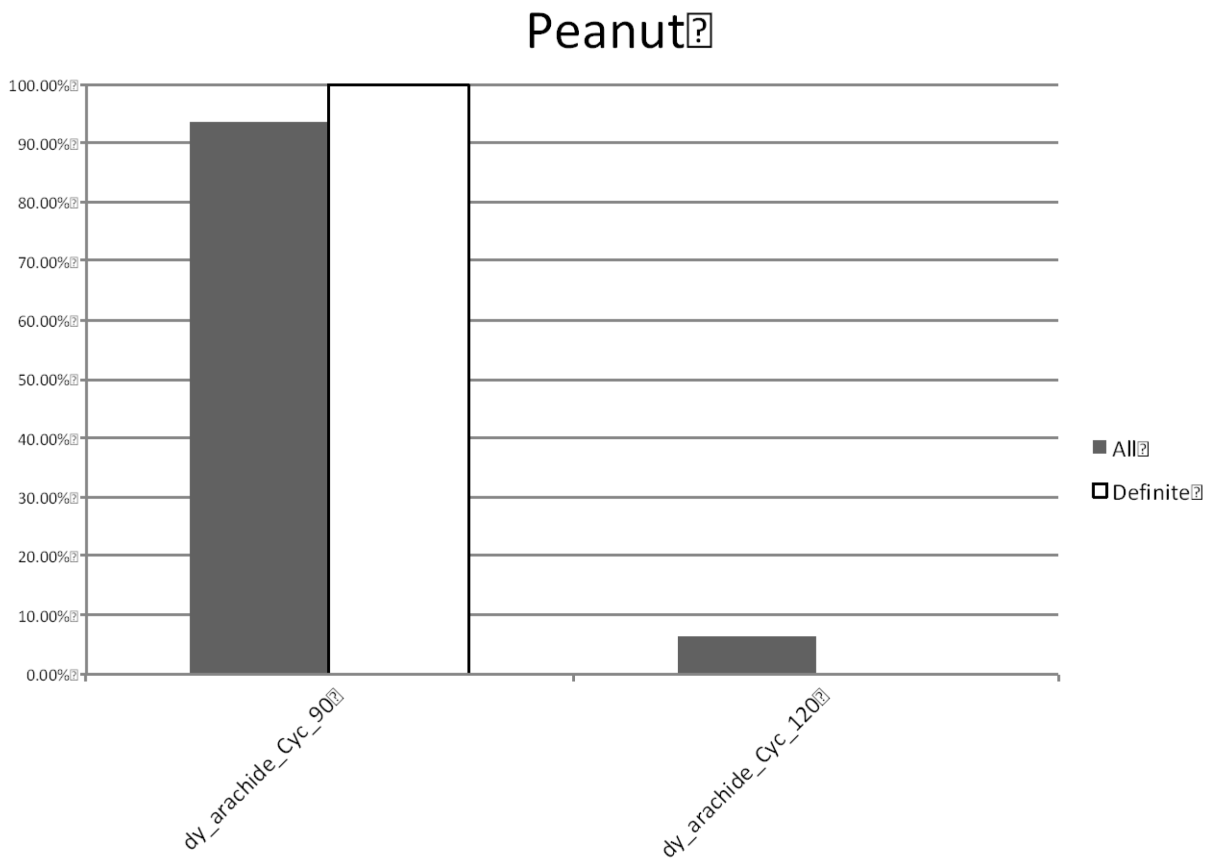



**Figure A77: Comparisons of peanut variety selection among junior women in GLAM villages, comparing all such women and those that used the advisories and accurately reported the workings of the program.**

Figure A78 illustrates the uses junior women put their crops to across the three village types. Junior women in all three villages exhibited a broadly similar strategy, growing staples for household consumption and marketing any surplus, and intermixing other crops that could be eaten or sold, depending on the harvest and market conditions. This made their production very flexible and resilient in the face of market and climate shocks. The strategies of junior women in these three villages appear to be very similar, with little indication that access to agrometeorological advisories impacted agricultural decision-making.

**GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat and sell equally |
| Okra | Eat more than sell |
| Cowpeas | Eat and sell equally |
| Onion | Sell more than eat |
| Rice | Eat more than sell |
| Millet | Eat more than sell |
| Tomato | Sell all |
| Lettuce | Sell all |
| Sorghum | Eat all |

**Former GLAM Junior Woman**

| | |
|---|---|
| Peanut | Eat and sell equally |
| Rice | Eat all |
| Fonio | Sell all |
| Okra | Sell more than eat |

**Control Junior Woman**

| | |
|---|---|
| Peanut | Eat and sell equally |
| Okra | Eat more than sell |
| Rice | Eat more than sell |
| Cowpeas | Eat and sell equally |
| Onion | Sell all |
| Sorghum | Eat more than sell |
| Chili pepper | Sell all |
| Tomato | Sell all |
| Soy | Eat and sell equally |
| Cotton | Sell more than eat |
| Bambara nuts | Eat and sell equally |
| Hibiscus | Eat and sell equally |
| Maize | Eat more than sell |
| Lettuce | Sell all |
| Tobacco | Sell all |

| Average | Interpreted value |
|---|---|
| 4.5-5 | Sell all |
| 3.5-4.49 | Sell more than eat |
| 2.5-3.49 | Eat and sell equally |
| 1.5-2.49 | Eat more than sell |
| 1-1.49 | Eat all |

**Figure A78: Intended uses of all crops on two or more junior women's farms, in GLAM, former GLAM, and control villages, for cluster 4.**

In cluster 4, junior women adopted similar agricultural strategies across all village types, mixing irrigated garden crops with some rain-fed crops. This likely rendered much of their production resilient in the face of climate variability. While there were some small differences in variety selection across village types, women generally had low rates of advisory use and the minimal difference in the selections of those using advisories and those living in GLAM villages more generally suggest that these differences are more likely a product of the influence of men's selections than they are representations of independent women's decisions about what to plant. Junior women in former GLAM villages had much higher rates of participation in livestock husbandry than their counterparts in GLAM or control villages, suggesting that their smaller set of cultivated crops might reflect the fact they were less reliant on agriculture for their incomes.

### 6.5.4. CLUSTER 4 SUMMARY

Possible Program Impacts

Those living in cluster 4 received the same advisories and advice as those in clusters 2 and 3, but again the actual selection outcomes in cluster 4 are somewhat different than in the other two clusters. This reflects a slightly different pattern of seasonal precipitation in this cluster vis-à-vis the other two clusters, suggesting that farmers were using local precipitation totals to calibrate their responses to the advisories.

In this cluster, there were no strong indications of impact from access to the agrometeorological advisories. There were few significant differences in crop selection, variety selection, or agricultural strategy between GLAM and other villages, and these differences were generally explained by different livelihoods opportunities and activities unrelated to the advisories. However, the wide distribution of varieties selected by farmers using the advisories is likely explained by the uneven pattern of rainfall across May. It is worth noting that in all cases except peanuts these selections emphasized the cycles promoted by the advisories. Therefore, the behavior of those farmers who understand the agrometeorological program is consistent with use of the advisories, even if this did not generate a significantly different pattern of variety selection than that seen in villages without the advisories.

In this cluster, farmers exhibited a tendency to focus their variety selection on a single cycle, making their individual farms very vulnerable to variable seasons. At the community level, however, there appears to be greater distribution of variety selection across cycles. If there is a mechanism for the distribution of agricultural risk at a scale larger than the household, it may be that these farmers were using the advisories properly. However, there is no evidence for such a mechanism in the data at hand.

Provisional decision-making model to inform future design

In cluster 4, men are the principal producers for market sale. Cotton is the key crop for this purpose, grown by both junior and senior men. Overall, men also grow staple crops with an eye toward producing a marketable surplus. Senior men seem less able to do so, likely because they are labor-constrained relative to junior men, but it does not appear that there is a fundamentally different view of agricultural strategy among senior men when compared to junior men.

Women in cluster 4 also produce for market sale and subsistence. They lack a single dominant cash crop, as they do not raise cotton. However, they do raise several vegetables for sale, and clearly intend to produce marketable surpluses of their staple crops. They are perhaps a bit more conservative in their strategies than men, likely because their production principally goes toward meeting subsistence needs within their households. Junior women appear to be a bit more aggressive in their market orientation, but as in the case of men, this may simply be because these women can work larger areas than senior women, allowing them larger farm returns. Senior women do own more livestock, which suggests that animal ownership is not gendered in this cluster, but a function of seniority. Their ownership of livestock explains their greater emphasis on sorghum production (for fodder). Junior women, on the other hand, are much more engaged with trading and business activities. It is not clear if this represents a generational shift in livelihoods emphasis, or simply reflects the fact that junior members of these communities have not yet had time to earn the funds necessary to accumulate livestock holdings and conduct business activities to facilitate animal purchases.

# 7. APPENDIX II: VILLAGE CLUSTERING METHODS

*JOHN KUPFER, UNIVERSITY OF SOUTH CAROLINA, EDWARD R. CARR, UNIVERSITY OF SOUTH CAROLINA*

## 7.1. CLUSTERING SAMPLED VILLAGES FOR ANALYSIS

The assessment of Mali's Agrometeorological Advisory program was conducted in villages spanning much of the southern part of the country. These villages were located across a range of climate/agroecological zones, and therefore residents of these villages have adopted particular mixes of livelihoods activities (i.e., the relative importance of farming, gardening, and pastoralism in local livelihoods) and crops/varieties appropriate to their setting. Rather than aggregate these disparate activities, crops, and experiences of the local environment into a single population for the purposes of analysis, the assessment team decided to disaggregate the villages into groupings whose similarity revolved around their shared agricultural practices, with a secondary focus on the degree of similarity between the suite of livelihoods activities they commonly practiced. The exercise was intended to return a large enough grouping of villages in each cluster to detect meaningful trends with regard to livelihoods decisions, agricultural decisions, and the impact of the advisories on agriculture and livelihoods without over-aggregating the data such that important regional differences disappeared in the analysis.

To better identify patterns of similarity in crop selection among the study villages, we used two multivariate analysis methods. The first, non-metric multidimensional scaling (NMS), is a non-parametric ordination technique that seeks to place *n* entities in a *k* dimensional mathematical space based on a dissimilarity matrix (Legendre & Legendre, 1998). Here, the entities are the surveyed villages, which were compared on the basis of the number of farmers who reported growing specific crops. As with results from methods such as principal components analysis (PCA), villages for which farmers reported similar crop selections have similar NMS axis values. Similarities in crop usage can then be visualized by graphing villages by their NMS axis values, with those having similar selections being located proximally in the graph. We selected NMS because it entails fewer data assumptions and has regularly been shown to be superior when compared to PCA and similar parametric methods.

Mathematically, NMS axis values were determined using pairwise (village-to-village) dissimilarities, which were calculated on the basis of crop selections using the Bray-Curtis coefficient. As a measure of dissimilarity, Bray-Curtis values range from zero (when two villages have the same number of farmers reporting the same usage of all crops) to one (when there is no overlap in crop selection among farmers between the two villages). To avoid results being biased by outliers, we deleted crops that were grown in only one village. The optimal number of NMS axes was determined by fitting the data using 1-, 2-, 3-, 4-, 5-, 6- and 7-dimensional solutions and plotting the Kruskal stress function, which measures the correspondence between the NMS solution and the original data, vs. the number of dimensions in an NMS scree plot. The starting configuration of the final NMS was derived from an initial run using 50 iterations. Relationships between village-level crop selections and livelihood activities as reported by those interviewed were clarified and graphed using Pearson correlation coefficients.

The second method, multivariate clustering, was used to group villages that exhibited similar patterns of crop selection. This approach focuses not on continuous variations in crop selection across villages (as NMS does) but rather seeks to identify groups of villages in which farmers made relatively similar crop selection. Clustering thus provides a complement to the NMS-based analyses.

Clustering was conducted using an unweighted group mean average method; to maintain compatibility with the NMS analyses, the distance measure used to cluster the villages was the Bray-Curtis coefficient, although other measures (e.g., Euclidean distances) yielded similar results. Rather than focusing on a specific number of village clusters defined *a priori*, villages were aggregated into two to seven groups, which were then examined as a function of crop selections and FEWS NET livelihood zones. Village clusters were also used to help interpret the NMS analyses. Both analyses (NMS and clustering) were conducted using PC-ORD v. 6.0 (McCune & Mefford, 2006).

## 7.2. RESULTS

The optimal NMS solution for village crop selection had two NMS axes and a low stress (12.8), suggesting a good representation of sites in mathematical space. As indicated in the NMS plot (Fig A79), villages at high NMS Axis 1 values were characterized by high reported levels of livestock husbandry (élevage) and handicrafts (artisanat), with the most distinctive crops being sesame, tomato, watermelon, pearl millet, groundnuts, and cowpea. A three group classification identified a cluster of nine villages having high NMS Axis 1 values (Figure A80a), all of which were associated with FEWS NET livelihood zone 9 (Figure A81). According to the livelihood profile for this zone, this area consists primarily of plains, hills and woodland and contains long stretches of the Niger and Sénégal rivers and "is primarily characterized by rainfed agriculture and sedentary livestock rearing." (http://www.fews.net/sites/default/files/documents/reports/ML_profile_en.pdf).

A finer four-class classification, however, indicated two distinct cropping patterns within this cluster of villages (Fig A80b). The first of these groups (located at high NMS Axis 1 and high NMS Axis 2 values and containing Fangasso, Samakale, Diouladiassi, Tomba, and Diassani) was characterized by greater cropping of peanut, okra, sorghum, tomato, and sesame. The second group (located at high NMS Axis 1 but low NMS Axis 2 values and including Diouna, Dioforongo, Konguena, and Zangonibougou) had more pearl millet, cowpea, and fonio.

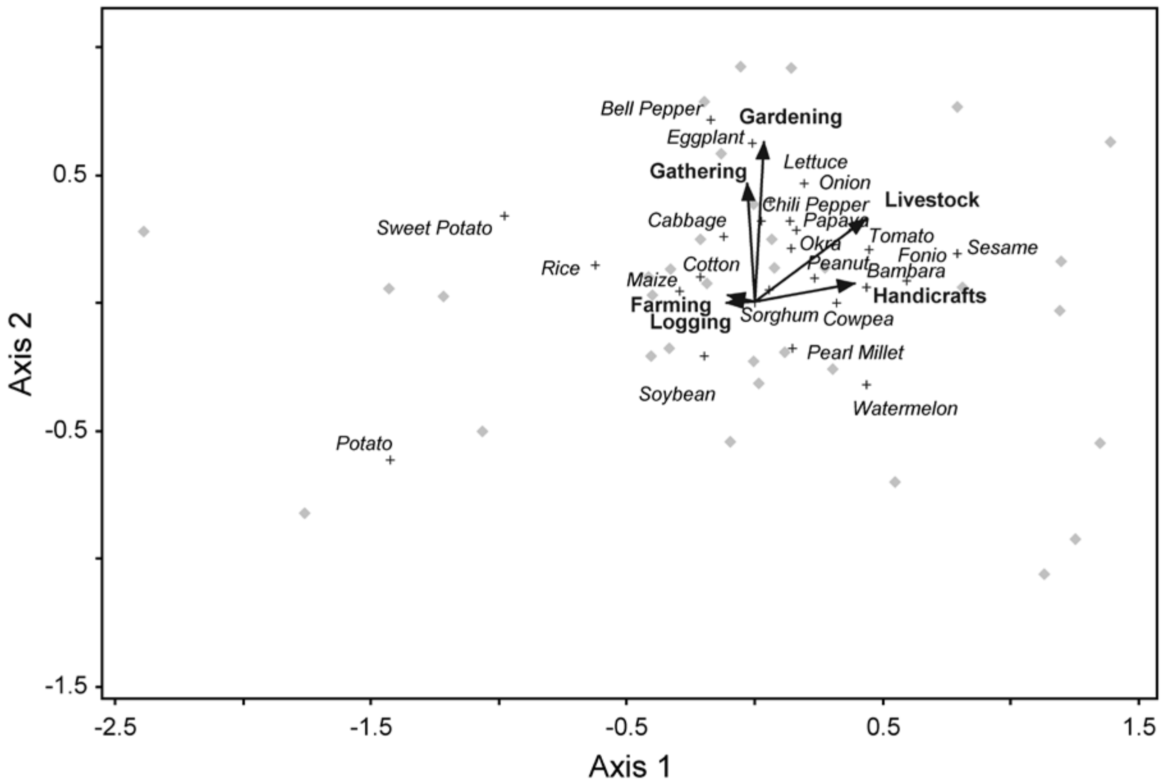



**Figure A79: NMS ordination of villages based on cropping patterns. Characteristic crops are indicated, and arrows display the association of villages with various livelihood activities. For example, villages in the upper center are associated with higher levels of gardening, which is coincident with greater cropping of bell pepper, eggplant, and lettuce.**

At the opposite end of NMS Axis 1, villages with low axis scores were characterized by greater growth of cotton, maize, rice, and a range of niche crops such as potato or sweet potato (Figure A79). The classification identified a group of five villages (Sanzana, Niagasso, Lobougou, Danderesso and Lolouni) at the lowest NMS Axis 1 values that were distinguished by especially high values of rice and maize and relatively low values of peanut cropping (Figure A80). These villages were located in or on the edge of FEWS-NET Livelihood Zone 11 (Figure A81), which is in the southernmost portion of Mali and generally receives the greatest amount of precipitation of the three livelihood zones covered in this study.

The remaining group, consisting of roughly 20 villages, was located at intermediate NMS Axis 1 values but covered a wide range of NMS Axis 2 values (Figure A79). Villages at high NMS Axis 1 values were distinguished by greater components of market gardening and picking/gathering wild plants and fruits; distinctive crop selections included peppers, eggplant, tomato, lettuce, onion and other garden crops. At lower NMS Axis 2 values, such crops declined and were replaced largely by pearl millet.

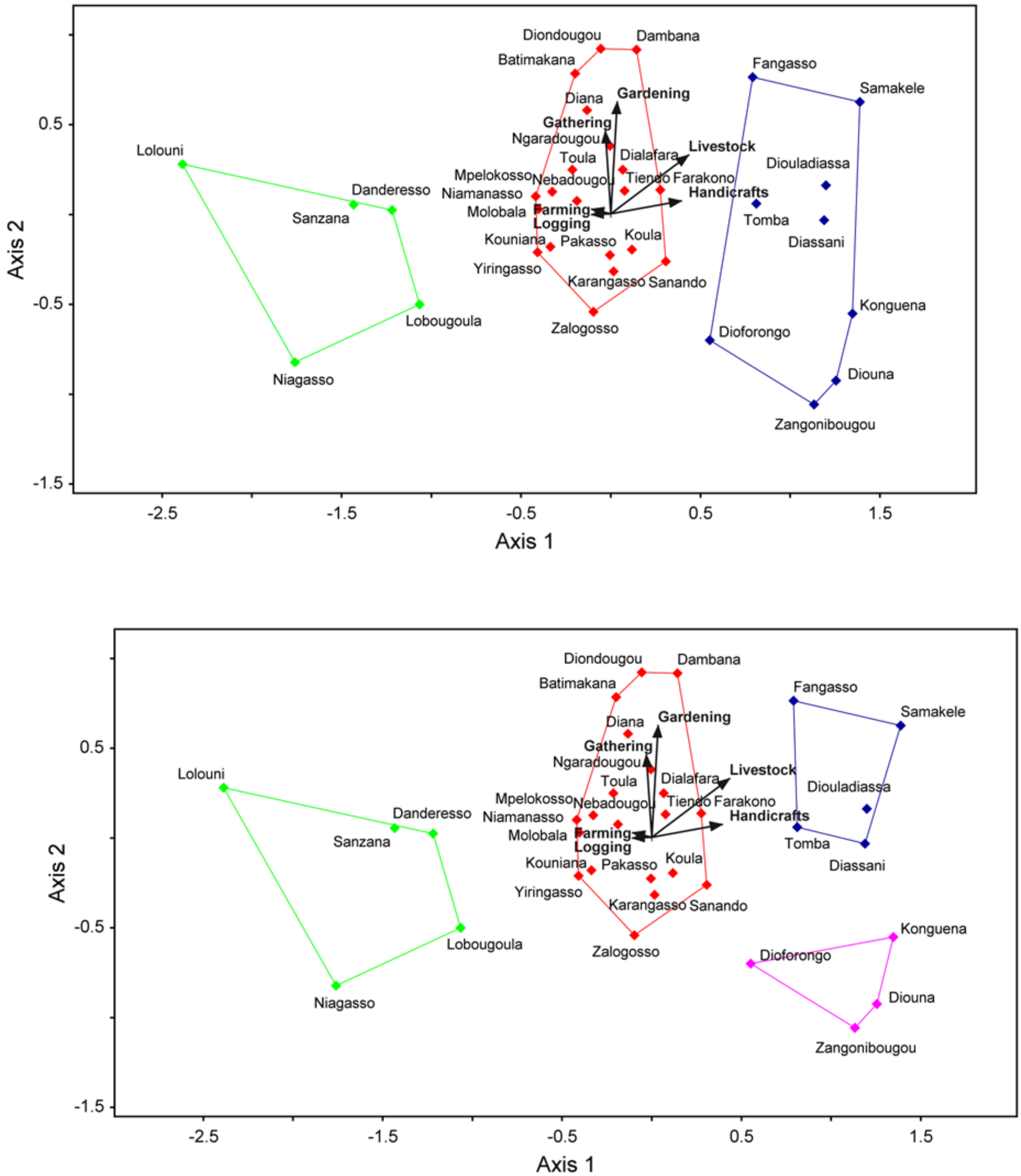



**Figure A80: Multivariate classification of villages based on crop selection, including (a) a three group classification, and (b) a four group classification. Village locations are arranged using the results of an NMS ordination based on cropping patterns.**

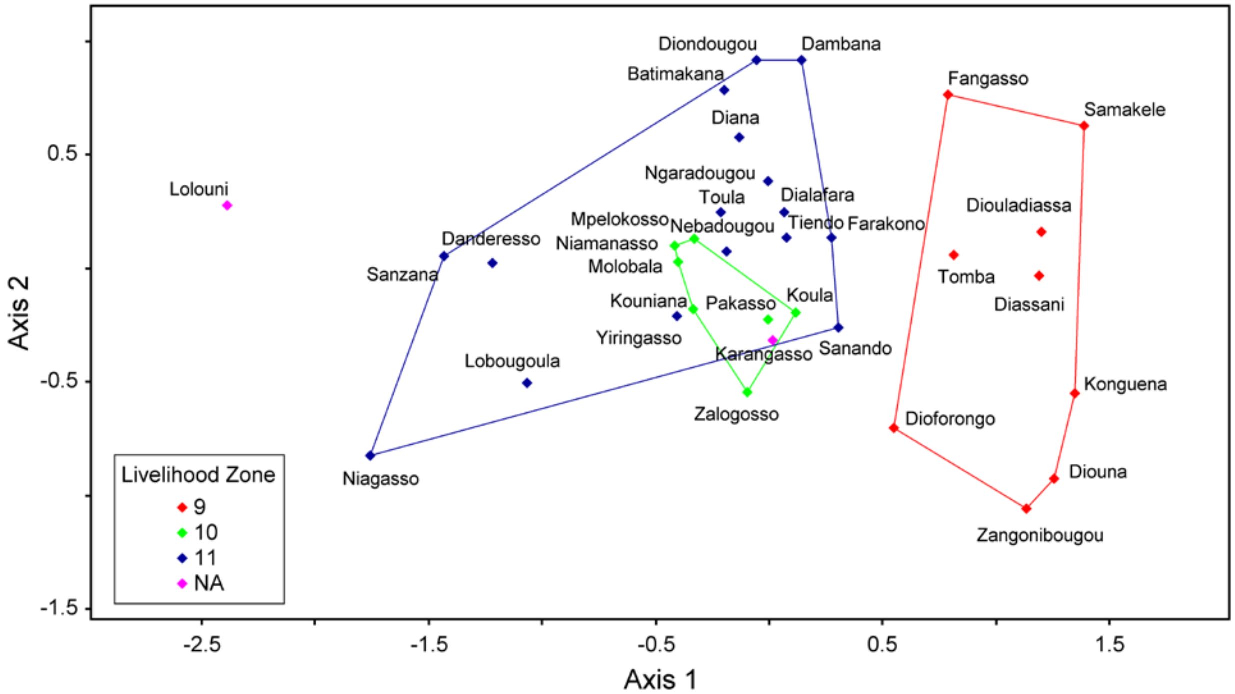



**Figure A81: Results of an NMS ordination of villages based on cropping patterns indicating FEWS-NET Livelihood Zones.**

It is worth noting that the gradient in crop selection that was manifested along NMS Axis 2 was generally captured by the FEWS-NET livelihood zones, with villages at high NMS Axis 2 values largely occurring in Zone 11 while those with lower NMS Axis 2 values situated in the generally slightly drier Zone 10 (Figure A81). Despite such differences, these villages were all identified as part of the same cluster (Figure A80).

**U.S. Agency for International Development**

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524

**www.usaid.gov**