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ENHANCING RESILIENCE TO WATER-RELATED IMPACTS OF CLIMATE CHANGE IN UGANDA'S CATTLE CORRIDOR (CHAI LL)

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Climate Change Adaptation and ICT

Enhancing Resilience to Water-related Impacts of Climate Change in Uganda's Cattle Corridor (CHAI ll)

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Research Institutions (listed alphabetically):

Climate Change Department, Ministry of Water and Environment
FHI 360
Uganda Chartered HealthNet
Uganda National Meteorological Authority, Ministry of Water and Environment
Wetlands Management Department, Ministry of Water and Environment
Zoology Department, Makerere University

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Abstract

The livelihoods of the Ugandan population are threatened by climate variability and change, which is manifested in escalating droughts, floods, and variability in the seasons. The cattle corridor, which covers 40% of Uganda's land, is prone to recurrent droughts and is one of the most affected areas in the country. Farmers receive little or no relevant information to help them cope with droughts and other climatic stresses.

Using Information and Communication Technology (ICT) tools in local languages, the second phase of the Climate Change Adaptation and ICT (CHAI-II) project provided adaptation information to over 250,000 farmers in three intervention districts through interactive FM radio broadcast, text messaging, email and face-to-face meetings including: seasonal weather forecasts and agricultural advisories localized to sub-county level; weekly livestock and crop market information to help farmers decide what, when, where and how much to sell; guidance on low-cost rainwater harvesting techniques; drought and flood coping mechanisms; and termite control measures. Two surveys, involving 644 (wave-1) and 813 (wave-2) households, were conducted to assess changes in adaptive capacity over time. The studies showed that 59% of the households in the intervention districts had access to adaptation information compared to 9% in the control district. The studies showed that the use of timely and locally relevant information reduced crop loss by 6% to 37% in the intervention districts compared to the control.

The study indicated that about 35% of the households are willing and able to pay for climate and agricultural information at US $4.07/household/year. A total cost of ownership analysis showed that the average total cost of ownership of the CHAI climate and agricultural information service per district is $96,079/year and TCO for expanding the solution nationwide is $11,721,638/year.

Key recommendations include expanding the observational networks and human resources of the Uganda National Meteorological Authority to support the generation of subcounty-specific seasonal forecasts and agricultural advisories; strengthening district-level governance for streamlining climate change adaptation activities; enhancing the Climate Change Department's eLibrary with localized climate change content; engage mobile network operators to co-finance expansion of the system by reducing text messages transmission costs; increasing the role of agricultural research organizations; and conducting further research to assess the pathways and determinants for scaling up ICT-based climate and agricultural information services in small-holder farming communities.

Keywords: *ICT and climate change, climate change adaptation, climate information, climate and agricultural information, adaptation information, e-adaptation, e-resilience, ICT4Ag, ICT in agriculture.*

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1. Synthesis

Climate change presents significant risks to the livelihoods and well-being of the Ugandan population. The "cattle corridor," covering some 40% of Uganda's land, is one of the areas most affected by the adverse impacts of climate change. Farmers receive little or no relevant information to help them cope with droughts and other climatic stresses. The Climate Change Adaptation and ICT (CHAI) project was designed to seek better understanding of the ways in which the ability of individuals and communities could be enhanced to improve their capacity to plan for, and respond to, climate-related water challenges using Information and Communication (ICT) tools. To achieve this goal, the project deployed an effective information delivery mechanism that leverages the use of mobile phones and traditional technologies such as community loudspeakers and FM radio transmissions for ICT-mediated dissemination of adaptation information in the cattle-corridor within three intervention districts (Nakasongola, Sembabule, and Soroti). One district (Rakai) served as the control.

The project disseminated to over 250,000 farmers climate and agricultural information including seasonal and 10-day forecasts specific to sub-counties, agricultural advisories to help farmers plan their crop/livestock farming in response to forecasted climate/weather conditions, weekly market information reports, low-cost water harvesting techniques, and termite control measures identified, packaged, and disseminated to communities via interactive FM radio broadcasts (talk shows and spot messages), SMS broadcasts, community loudspeakers, and face-to-face meetings.

To assess changes in access to climate and agricultural information and improvements in crop loss because of applying acquired information into action, the project conducted two studies involving 644 households in September 2016 and 813 households in September 2017. The studies showed that, on average, about 6 out of 10 households in the intervention districts received information from the project while only 1 out of 10 households in the control district received information from other sources. Results from the first wave of the study conducted in September 2016 show that the control district of Rakai sustained the highest crop loss and damage ($520/year/household) followed by Sembabule ($464/year/household), Soroti $303/year/household), and Nakasongola ($209/year/household). The average monetary value of crop loss for the intervention districts was $325/year/household showing that the control district of Rakai sustained 37% more crop loss than the intervention districts. During the second wave of the study (Sept 2017), the average monetary value of crop loss for the intervention districts was $203/year/household while the control district of Rakai sustained $192/year/household showing that the control district of Rakai sustained 6% less crop loss than the intervention districts.

A willingness and ability-to-pay study conducted by the project showed that about 35% of the households were willing to pay for climate and agricultural information an average of $4.07/household/year. A Total Cost of Ownership (TCO) analysis was conducted to determine the costs involved in the generation and dissemination of climate and agricultural information in local languages to small-holder farmers. The analysis showed that the average total cost of ownership of the CHAI climate and agricultural information service per district is $96,079/year and TCO for expanding the solution nationwide is $11,721,638/year.

To support the sustainability and long-term success of the ICT-based climate and agricultural information system and assist smallholder farmers to minimize crop losses due to climate-related hazards, the following are recommended.

Expand observational networks of UNMA: The availability of well-maintained and dense observational networks for weather and climate is of critical importance for seasonal forecasting and other weather-dependent sectoral applications especially for the agriculture sector. UNMA assessments show that, currently, out of 20 agrometeorological zones in Uganda, only 8 have observation stations; out of 20 hydro-meteorological zones, only 6 have observation stations; out of 600 rainfall zones, only 150 have stations. As a temporary measure, the project, working with UNMA, installed 22 rain gauges at the subcounty level in the intervention districts. However, to generate reliable seasonal and 10-day weather forecasts and agricultural advisories localized to the subcounty-level, UNMA needs to make significant investments to expand its observational network coverage. In areas where manual instrumentation is installed, it is recommended that UNMA use the mobile application developed by the project for capturing daily weather data and submitting it to the server installed by the project at UNMA in Kampala.

Strengthen UNMA human resources: The generation of location-specific climate and agricultural information requires a dedicated team of weather forecasters and agro-meteorologists. The number of forecasters and agrometeorology during the study was only 4, which is far below the required number. It is recommended that the number of forecasting and agrometeorology team be increased to 12 – 14 to enable them to generate subcounty specific seasonal forecasts and agricultural advisories. Uganda is delineated into 16 climatological zones based on principal component analysis with each of the zones having their own characteristics and it is recommended that forecasters be assigned to a specific zone(s) to enable them to build unique capabilities related to the zones and improve the accuracy of forecasts through iterative model selection.

Strengthen district-level climate governance: At district local government level, climate change activities are coordinated by the District Environment Committee chaired by the Chief Administrative Officer with the district Natural Resources and Environment officer serving as secretariat. The district Environment Committees played a crucial role in streamlining the localization and delivery of climate and agricultural information in the district. However, the operationalization of the district Environment Committee is not consistently implemented throughout the country. It is recommended that the CCD provide ongoing support to district local governments to establish and operationalize the district Environment Committee.

Strengthen CCD's eLibrary with localized climate change content: The CCD has developed an eLibrary to serve as a knowledge base for supporting climate change mitigation and adaptation actions in Uganda. The project has been using the CCD's eLibrary as the source of climate information for dissemination to small holder farmers in the intervention districts. However, the eLibrary has few resources that are locally developed and a limited amount of content that can be used by less-educated rural smallholder farmers. Addressing the lack of locally relevant climate and agricultural content is critical to ensuring that the transformative potential of this approach is fully maximized by smallholder farmers. Towards this end, it is recommended that the CCD introduce a content curation approach for selecting, organizing, localizing, and presenting climate information that is meaningful to smallholder farmers.

Engage private sector to co-finance expansion: The annual total cost of ownership for national expansion of the climate and agricultural information system is $11,721,638/year. The TCO analysis conducted by the project showed that a 10% reduction in the cost of sending/receiving SMS messages reduces the total cost of ownership by close to 9%. For example, reducing the current per outgoing SMS message rate of 35 UGX (US $0.01) by 10% (making the rate per outgoing SMS message 31.5 UGX), the annual total cost of ownership will reduce from $11,721,638/year to about $10,690,134/year. Each 10% reduction in the per outgoing SMS rate will result in the reduction of over $1 million in the annual total cost of ownership of the system. It is therefore recommended that the Ministry of Water and Environment negotiate with mobile network providers to reduce the rates associated with the delivery of information via SMS. The mobile network operators indicated their interest to negotiate favorable rates with pertinent bodies of the government.

Increase the role of agricultural research organizations: Agricultural research organizations such as the National Agricultural Research Organization provide (NARO) support for the generation of yield-enhancing technologies. However, their role is limited to agricultural technology development and not dissemination; while CHAI's role is to disseminate technologies that are suitable for current climatic conditions. The linkage between NARO the CHAI initiative was weak and a key recommendation is to actively engage NARO to facilitate the dissemination of proven agricultural technologies to farmers through the CHAI platform.

Conduct ongoing research: Conduct further study to determine how ICT-mediated climate and agricultural information delivery service like the CHAI model can be scaled-up most effectively as a responsive and adaptive system for achieving comprehensive impact. In conducting the proposed investigation, the role of field demonstrations of weather forecast-based farming for farmer adaptation and uptake using participatory approaches should be assessed.

2. Research Problem

A landmark report by the UN Intergovernmental Panel on Climate Change (IPCC) released in October 2018 notes that the effects of global warming, which has already reached 1°C over preindustrial times, are being observed through more extreme weather, greater frequency of heat waves, rising sea levels, melting ice, floods, severe storms and droughts (IPCC 2018). In Uganda, climate change poses great risks to the well-being of the population. Changes in climate are already threatening Uganda's ecosystems and the livelihoods of those that depend on them and increasing the frequency and intensity of severe weather events such as droughts and floods (Uganda NDC 2018).

Uganda's Nationally Determined Contribution (NDC) Partnership Plan established that climate variability and climatic change[1] are evident in the country in the form of escalating droughts and floods, and altered seasonal variations, especially changes in the onset and cessation of rains (Uganda NDC 2018). Studies show that the impacts on agriculture, health, and water in Uganda and found that Uganda experienced seven droughts between 1991 and 2000 (Magrath 2008). During the 80-year period from 1911 to 1990, eight droughts occurred, while in the 10 years between 1991 and 2000, Uganda experienced seven droughts. Since 1960 mean annual temperatures in Uganda increased by 1.3ºC, rainfall became more unpredictable, and extreme events such as droughts and floods increased in frequency and intensity (Uganda NDC 2018).

The Ugandan economy and the wellbeing of the population are both highly dependent on the availability of adequate water supply. While Uganda's climate offers great potential for food production, prolonged dry spells and frequent droughts in many parts of the country, especially in the cattle corridor, have led to dependency on food aid (FAO 2010). Agriculture accounts for 41% of the GDP, employs 80% of the labor force, and supplies 85% of exports. It is primarily rain-fed and thus vulnerable to climatic variations (UIA 2009). Higher average temperatures and more frequent and severe climatic incidents result in diminishing food security, decreasing quantities and quality of water, and deteriorating natural resources, negatively affecting health, settlements, and infrastructure (UNDP-UNEP 2009). The destructive impact of droughts and floods continues to be felt by the population and the national economy. Preliminary analysis conducted by the United Nations International Strategy for Disaster Reduction in 2011 using Uganda's national disaster loss database showed that over 50% of the Ugandan population are affected by drought and 18% are affected by floods (UNDP-UNEP 2009).

[1] According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" while climate variability refers to the "variations in the mean state and other statistics the climate on all temporal and spatial scales beyond that of individual weather events".

The 2011-12 annual performance report of the Government of Uganda (GOU) cites drought as one of the main reasons for achieving only 3.2% GDP growth against a projected growth of 7% for the reporting period (GOU 2012).

The “cattle corridor” of Uganda is one of the hardest hit areas due to the impacts of climate change and variability. The cattle corridor is a semi-arid ecosystem that covers 40% of Uganda’s land and is characterized by scanty, unreliable rainfall (450 – 800 mm/year) compared to other areas such as Entebbe (1,574 mm/year). It is subject to recurrent droughts and has sparse vegetation. Considered one of the most fragile areas in Uganda (Lufafa 2006) and particularly vulnerable to climate change (Uganda NAPA 2007), the cattle corridor experiences higher proportions of water stress than other parts of the country. The scarcity of water resources for human and livestock consumption in the cattle corridor has been linked to increased temperatures, seasonal shifts, reduced rainfall, and lower water quality through siltation and pollution. Already evident in these districts, climate change and the diminishing availability of water are likely to reduce incomes (Nakasongola District Council 2004). Communities living in the cattle corridor are experiencing food insecurity due to reduced production of major crops caused by the increased occurrence of droughts. Other major impacts of climate change already evident include the displacement and migration of people and livestock in search of scarce water and food, the destruction of infrastructure due to flooding, and the breeding of conflict among communities over limited water resources and pasture (UNDP-UNEP 2009).

In its pursuit of a sustainable future, in 2015, the international community made an extraordinary set of commitments to minimize global warming and its impacts through the Paris Agreement, the Sustainable Development Goals (SDG), and the Sendai Framework for disaster risk reduction 2015 – 2030. Adapting to the impacts of climate change is one of the key objectives of the three post-2015 landmark global agendas. The SDG clearly articulates the impediments of climate change in pursuing sustainable development and that climate change “is one of the greatest challenges of our time and its adverse impacts undermine the ability of all countries to achieve sustainable development” (UN 2015). Likewise, the Sendai Framework[2] note that “disasters, many of which are exacerbated by climate change and which ae increasing in frequency and intensity, significantly impede progress towards sustainable development” (UN 2015).

There is a widespread recognition that ICTs are one of the key pillars of the world’s digital economy and have tremendous potential to facilitate the achievement of the Sustainable Development Goals and improve people's lives. Member countries of the United Nations recognize that the use of ICTs can accelerate action of SDGs in multiple ways including

[2] The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) is one of the major agreement of the post-2015 development agenda, which was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR).

accelerated rollout of services in multiple sectors including health, finance, education, and agriculture; reduce the cost of deploying health, education, financial and other services; increase public engagement and awareness of new opportunities through rapid information exchange; and provide low-cost platforms for workforce training through online medium (Ericsson, 2016). A research conducted by Ericsson and the Earth Institute on the role of ICTs for achieving the SDGs concludes that “every goal—from ending poverty and halting climate change to fighting injustice and inequality—can be positively impacted by ICT” (Ibid).

In January 2012, FHI 360, Uganda Chartered HealthNet (UCH), Uganda Ministry of Water and Environment/MWE (Climate Change Department/MWE, National Meteorological Authority and Wetlands Management Department), Makarere University (College of Agricultural and Environmental Sciences and Department of Zoology) with funding from the International Development Research Centre, Canada (IDRC) launched a pilot Climate Change Adaptation and ICT (CHAI) project. The CHAI pilot project was designed to foster community adaptation to climate change-induced challenges by developing and testing the effectiveness of an information and communication technology-based system for the collection, reporting, analysis, and dissemination of information on water-related climate hazards, risks, and adaptation mechanisms. The study was conducted in the cattle corridor within three intervention districts (Nakasongola, Sembabule, and Soroti) and one control district (Rakai).

While the CHAI pilot intervention proved that the use of ICT tools for providing climate services increased access to effective adaptation information and resulted in significant reduction of crop loss and damage, new issues and research questions emerged from the study. We affirmed that adaptation is largely a behavioral response by individuals, communities, and institutions to current or forecasted climatic changes. Instilling a willingness among agro-pastoralist communities to modify behavior in response to changing climate proved to be a slow process; we determined that how these communities respond to changing or variable climate needed to be studied over a longer period. We also realized that while the Ministry of Water and Environment had expressed interest in rolling out the system built by the project, the financial, institutional, and technical requirements for sustaining and scaling the system needed to be established before the project could be handed over to the ministry.

The second phase of CHAI (CHAI-II) aimed to build on the CHAI pilot to develop a sustainable and scalable ICT-based climate change adaptation information generation and dissemination model that will support the actions of the Ministry of Water and Environment to enhance the adaptive capacity of individuals and communities exposed to climatic hazards. Building on the base established by the CHAI-pilot (CHAI-I), the research questions we proposed to answer through CHAI-II included understanding the longer-term benefits of ICT-mediated climate services delivery in improving the adaptive capacity of the communities and the technical, financial, institutional support, and coordination requirements needed for sustaining and scaling the climate change adaptation information system.

Improvements in access to climate information; impacts in minimizing crop loss and damage; the roles that government and other institutions would play in scaling and sustaining the climate information delivery model; communities' willingness and ability to pay for climate information; and the total cost of ownership for the generation and dissemination of climate and agricultural information using the CHAI model were assessed to help answer the research questions.

3. PROJECT OBJECTIVES

3.1 Objectives

The primary objective of CHAI-II was to develop a sustainable and scalable ICT-based climate change adaptation information generation and dissemination model that would support the actions of the Ministry of Water and Environment to enhance the adaptive capacity of small-holder farmers exposed to climatic hazards.

The **specific objectives** of the project were:

- To determine the longer-term benefits of ICT-mediated adaptation information delivery for improving crop yield and the income of communities;
- To determine the technical, financial, institutional support, and coordination requirements needed for sustaining and scaling the climate change adaptation information system developed by the project; and
- To inform policy makers and the processes they develop with research-based evidence on the role and potentials of ICTs for improving the livelihood of rural communities.

3.2 Research Questions

The key research question addressed by the project were:

Question 1: What are the longer-term benefits of ICT-mediated adaptation information delivery in improving the adaptive capacity of the communities?

Question 2: What are the technical, financial, institutional support, and coordination requirements for sustaining and scaling the climate change adaptation information system?

From these questions, the following sub-questions were developed based upon the lessons learned from CHAI-I.

The sub-questions for ***research question 1*** were:

1. Is access to climate information improved?
2. Are recipients of the information acting on received information?
3. What are the impacts of ICT-mediated adaptation information in minimizing crop loss and damage?

The specific questions for ***research question 2*** were:

1. What roles would the government and other local institutions play in scaling and sustaining the adaptation information delivery model developed by CHAI?
2. What is the total cost of ownership of implementing the CHAI model of adaptation information generation and dissemination?
3. What are households willing and able to pay for adaptation information?

3.3 Project Duration

The CHAI-II project was implemented over a period of 28 months from October 2015 to January 2018. The findings of the studies conducted by the project are provided in this final technical report.

4. RESEARCH METHODOLOGY

4.1 Conceptual Framework

The economy and the people of Africa are highly dependent on natural resources for their survival. The agricultural sector accounts for over 17% of their Gross Domestic Product and employs over 60% of the total labor force. In addition, over 80% of their population lives in rural areas and depends mainly on agriculture for their livelihood. Due to its high exposure to climatic hazards, low adaptive capacity, and dependence on the use of natural resources, Africa continues to be one of the most vulnerable continents to climate change and climate variability (IPCC 2014). Weak adaptive capacity throughout the region is the result of multiple interrelated challenges including poverty, population increase, complex governance and weak institutional capacity, and ecosystem degradation that in turn contribute to the continent's greater vulnerability to climate change. In Uganda, higher average temperatures and more frequent and severe climatic incidents such as droughts and floods result in diminishing food security, a decrease in the quantity and quality of water, and deteriorating natural resources, negatively affecting health, settlements, and infrastructure. The destructive impact of droughts and floods is felt by the population and the national economy. The 2011/12 annual performance report of the Government of Uganda cites drought as one of the main reasons for achieving only 3.2% GDP growth against a projected growth of 7% for the reporting period (GOU 2012).

Several definitions of adaptation and adaptive capacity can be found in the literature. the CHAI project adopted the definitions provided by the IPCC for developing the conceptual framework. Thus, *adaptation* refers to "adjustments in individual, community, and institutional behavior to reduce vulnerability to climate change including climate variability and extreme events" and *adaptive capacity* refers to "the ability of individuals, communities, and institutions to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences." The individuals and communities are those living in the cattle-corridor of Uganda whose livelihood depends on livestock and subsistence crop farming. The institutions include the local government including district level departments of Production, Water, Natural Resources, Commerce, Community Development, and Communications, and national level entities involved in the generation and dissemination of climate information including the Meteorological Authority, the Climate Change Department, and various research institutions.

The key determinants of adaptive capacity are economic resources, technology, information and skills, infrastructure, institutions, and equity (Smit 2001). Increased access to economic resources increases adaptive capacity, while the lack of it limits adaption options. Improved technology and access to technological outputs such as drought and heat resistant seeds increases the range of potential adaption options. Greater access to information increases the likelihood of appropriate and timely adaptation, while the lack of informed and skilled personnel and farmers reduces the ability to apply appropriate adaptation actions. The availability of infrastructure such as water harvesting dams for domestic and agricultural water supply, roads, and communication networks can enhance adaptive capacity. Well-developed and functioning institutions at local and national levels help reduce the impacts of climate-related risks and increase adaptive capacity by increasing access to locally relevant information and supporting households by providing them with the resources needed for acting on received information. Differential distribution and access to information, economic, technological, and infrastructural resources among the affected population imposes constraints on adaptive capacity, while equitable distribution of such resources increases adaptive capacity (Smit 2001).

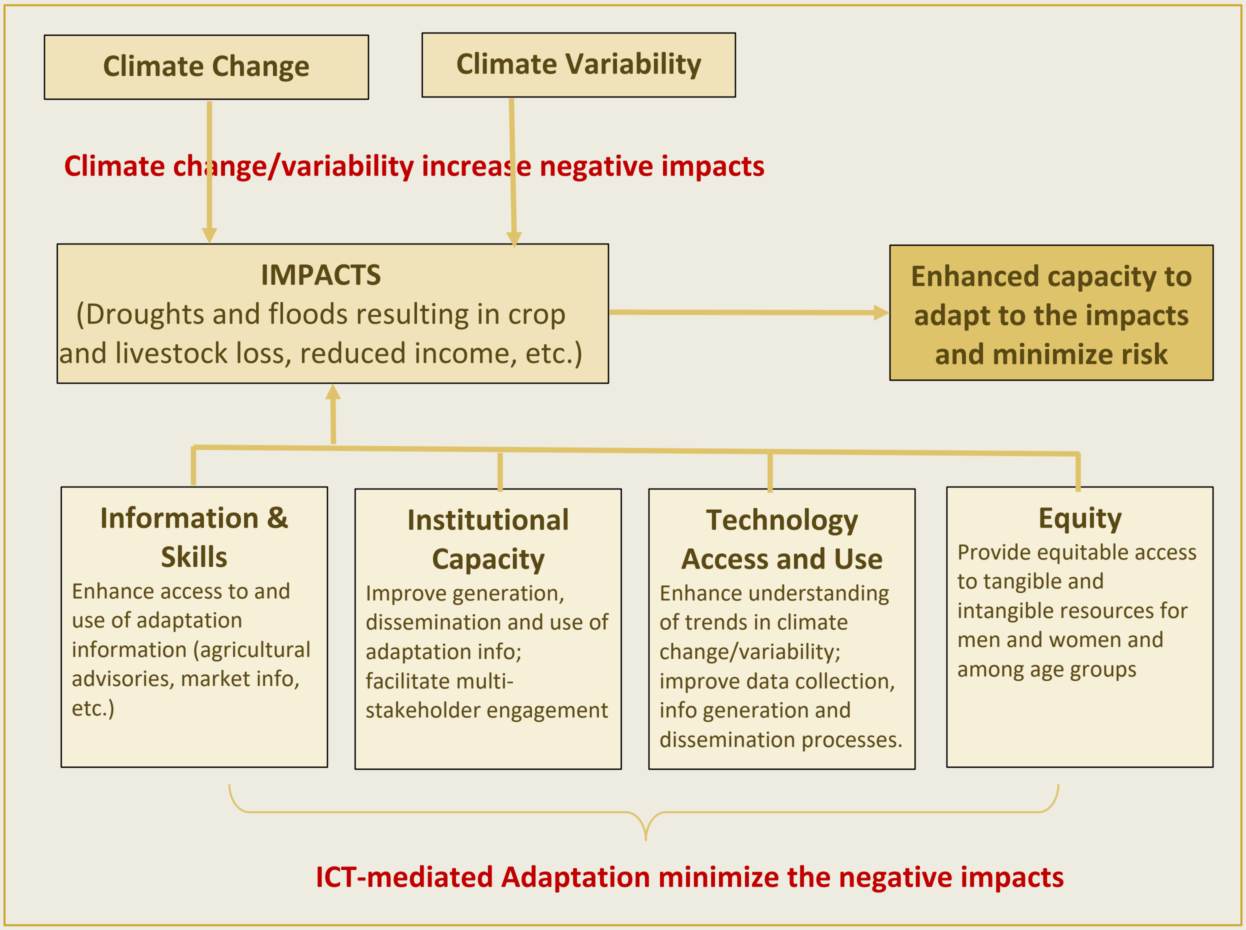

Figure 1: Conceptual framework: Enhancing adaptive capacity of affected farmers through ICT-mediated adaptation

The project focused on enhancing the following four determinants of adaptive capacity using ICT tools and processes.

Information and Skills

The rationale for this determinant is that "successful adaptation requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess them, and the ability to implement the most suitable ones" (Fankhauser 1997). Building on the experiences drawn from the pilot implementation of CHAI, the project transmitted the following types of adaptation information to communities to increase their access to adaptation information and build their skills to act on received information.

Seasonal and 10-day weather forecasts: High quality seasonal forecasts (3-months duration) and 10-day weather forecasts can help crop farmers and pastoralists make informed choices about the management of their livestock and crops. The full content of the seasonal and 10-day forecasts was broadcast in local languages to the communities in the intervention districts via FM radio and printed bulletins posted in community gathering places. Summaries and brief updates of the forecasts were disseminated via Short Message Service (SMS) or text-messaging to individuals who use mobile phones. The CHAI-pilot showed that providing farmers with information on the onset, cessation, and intensity of rainfall is not enough to help them act on the information. The delivery of seasonal forecasts must be accompanied with face-to-face meetings with extension agents who are available at least at sub-county level. The extension agents received the same set of information and they provided guidance through participatory discussions with farmers at each village.

Climate-based agricultural advisories: Over 80% of the population in the pilot districts is dependent on livestock and crop agriculture and studies conducted by the project showed that 98 – 100% of the households in the pilot districts were confronted with drought that results in severe livestock and crop losses. The delivery of climate-based, location-specific (at sub-county level) agricultural advisories helped the farmers to minimize the impacts of drought on livestock and crop productivity.

Crop and livestock market information: The most immediate effects of drought and floods is a fall in crop production due to poorly distributed and inadequate rainfall and increased death rates among livestock due to reduced availability of fodder resulting in continuously declining live weight and increased susceptibility to disease. Those whose livelihood is drawn from crop and livestock farming are faced with inadequate harvest to feed their families. In times of drought, there is an increased need to buy grains by pastoralist households due to falling supplies of milk. In times of hardship, farmers are forced to sell their livestock to meet their daily nutritional needs. Local traders traveling to villages usually buy livestock and crop on their own terms because the farmers are not aware of current market prices in urban or semi-urban market outlets. The economic loss due to the drought-induced distress sale of livestock and crops in the cattle corridor is substantial. The dissemination of market prices from local outlets was designed to help community members decide what and where to sell and to minimize economic losses incurred by selling assets below market value.

Other location specific adaptation information: The project worked closely with district and national level institutions to generate and disseminate other location-specific adaptation information. Examples include:

Rain water harvesting techniques: Working with water and production officers in the intervention districts, the project generated information on low-cost water harvesting techniques including the design, cost, operation, maintenance, and suggested uses of the harvested water. The full content of such information was broadcast via interactive radio programs in collaboration with local FM radio stations and posted on community bulletin boards. Short summaries were produced for transmission via text messaging.

Flood coping mechanisms: Flooding affects only the low-lying areas of one of the three intervention districts. Working with the Meteorology Authority and district-based departments, the project generated information on how to cope with, survive, and recover from flooding hazards for rural communities in the flood-prone areas of Soroti district. Examples of adaptation information that were transmitted included how to protect water sources from contamination during flooding; how to keep water safe at the household level; how to minimize the risk of water-related diseases that proliferate after flooding events; how to construct low-cost housing using materials that withstand flooding; how to select safe locations for building residential houses; and how to minimize flooding damage of household assets. Such information was disseminated via interactive radio programs and posted on bulletin boards. A summarized version of the information was developed to elicit discussion and questions and were transmitted via text messaging.

Termite control: Termites that feed on live plants and organic matter and that cause significant damage to crop, seedlings, grass, trees, wood fence pickets, and wood houses are a major problem in Nakasongola district. Termites' foraging activity in this district is intensified during water stress. Working with district level departments, the project generated and transmitted termite control information. As with the other information resources mentioned above, appropriately formatted content was transmitted via interactive radio, bulletin boards, and text messaging.

Institutions

The rationale for this determinant is that "well-developed social institutions help to reduce impacts of climate-related risks, and therefore increase adaptive capacity" (Smit 2001) and institutional constraints limit access to resources for communities affected by climate variability and change thereby increasing their vulnerability (Kelly 1999). Research shows that information delivery using ICT tools alone cannot provide a meaningful contribution to development if the communities do not have access to resources and institutional and/or social infrastructure that will enable them to act on decisions made with the acquired adaptation information (Heeks 2005).

The project strengthened the institutional set up to support the generation, dissemination, and use of adaptation information in the pilot districts.

Level	Institution	Primary Role	Instrument
National	1. Climate Change Dept 2. Meteorology 3. Wetlands Management 4. Research organizations	1. Climate awareness info 2. Climate information 3. Wetland management info 4. Agricultural technologies	Steering Committee
District	1. Production 2. Natural Resources 3. Water 4. Commerce 5. Community Dev 6. Communications	1. Localize climate/agr info 2. Environmental management 3. Water harvesting 4. Market information 5. Market and link with HHs 6. Overall communication	District Climate Information Committee
Sub-county	1. Community Development Officers 2. Weather data recorders 3. Local council members	1. Market data collection 2. Weather data collection 3. Support project activities in the sub-county	Sub-county level meetings
Village	1. Farmers groups 2. Local council members 3. Community leaders	Receive and share adaptation information with farmers in the village	Village meetings

Figure 2: Institutional arrangements for the generation and dissemination of climate/agricultural information

The institutional framework included a Climate Information Committee composed of the district level technical departments to oversee the localization of adaptation information to local needs and priorities. Extension agents in each district provided ongoing advice and consultations to farmers. Public and non-governmental organizations working in the districts were linked with households and encouraged to provide support that enables households to act on the information received. The project built the capacity of the support institutions on multiple fronts. Progressive and ongoing capacity building was provided to the district governments on the integration of the livestock and market information system into the districts' business processes. The capacity of UNMA was strengthened to enable them to manage and use the mobile-based weather data collection and transmitting system developed by the project. The financial, technical, and institutional coordination requirements needed for sustaining and scaling the institutional framework was determined by the project. Such targeted interventions were designed to enhance the capacity of the institutions to provide ongoing support to the communities affected by climate variability and change.

Technology

The reasoning for inclusion of this determinant is that the "lack of technology limits the range of potential adaptation options" and that most of the adaptive strategies for the management of climate variability and change involve technology (Smit 2001). Communities' and support institutions' ability to use and develop technologies are important determinants of adaptive capacity (Smit 1997). Some of the major information and communication challenges faced by UNMA in the generation and dissemination of adaptation information include a limited weather observation network, delays in data capture and transmission to national entities for analysis, the inability to localize and package climatic information, delayed delivery of information, and a fragmented early warning system.

As shown in the following diagram, climate/agricultural information system developed by the project is comprised of three major components: daily weather and market data collection and submission; climate/agricultural information generation; climate/agricultural information dissemination to farmers and support groups.

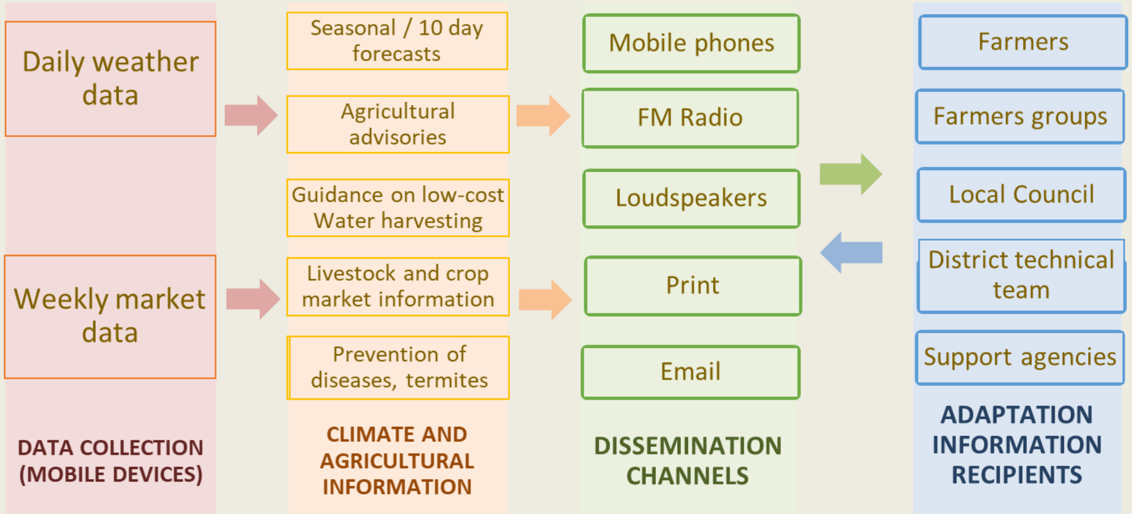

Figure 3: Overall configuration of the adaptation information system

The project strengthened UNMA capacity to develop and use mobile phone applications for collecting daily weather data from rural locations where there are no automatic weather stations. The use of improved ICT tools was designed to enable UNMA to generate more reliable and locally relevant adaptation information. Community members usually do not know who to contact for additional information and/or resources to help them act on received information. The project used mobile technology tools to link households with support institutions that have the resources to help them transform acquired knowledge into action.

Detailed description of the technology components of the system is provided in the section "**4.2.1 Major Technology Components**"

Equity

The foundation for this determinant is that the extent to which "communities are 'entitled' to draw on resources greatly influences their adaptive capacity and their ability to cope" (Smit 2001). The key resources made available by the project were information resources to inform individuals and communities on appropriate adaption actions. There is ample evidence showing that climate change affects men and women differently due to differences in their roles prescribed by cultural traditions, societal norms, physiological make up, and livelihoods. Research shows that women "have a definite information deficit on climate politics and climate protection" raising "the question of how the subject is communicated" (Rohr, 2006). The project designed appropriate methods addressing gender and other social norms for developing adaptation information content and for ensuring that information resources are delivered equitably to women, men, and different age groups.

To ensure that the adaptation actions promoted by the project address the needs and priorities of women, the differentiated impacts of climate change on men and women were assessed through household surveys. The framework for addressing the specific needs of women and other vulnerable groups involved the following.

- Assessment of the adaptation information needs of women and men;
- Assessment of the technology and communication channels preference of women and men; and
- Assessment of women and men's knowledge regarding risks related to climate change, strategies and coping mechanisms in response.

Based on such assessments, climate and agricultural information content were packaged addressing the needs of women and men. Likewise, communication channels were selected in a manner that meets the preferences of women and men. For example, women tend to listen to radio programs around 6 – 7 pm and climate and agricultural information targeting women were disseminated around this time. During radio talk shows for the interactive dissemination of climate and agricultural information, female technical experts and members of parliament invariably participated to ensure that women equally participate in knowledge sharing.

4.2 Interventions

The findings of the CHAI-pilot project were used to inform the design and enhancement of a climate information system to support the generation, dissemination, and use of climate and agricultural information. Key considerations from CHAI-pilot that guided the design of the system include the following.

Address climate and agricultural information needs: The major climate and agricultural information needs of farming households include accurate and seasonal forecasts localized to sub-county level; weather-informed agricultural advisories such as types of crop to plant; guidance on low-cost water harvesting techniques; livestock and crop market information derived from local market outlets; and termite control advice to help communities avert livestock and crop losses. The CHAI-II interventions addressed those priorities.

Improve accuracy of weather forecasts**:** The key factors that impede UNMA's ability to generate accurate localized seasonal forecasts (three-months duration) for minimizing the impacts of droughts are the limited numbers of weather stations for gathering observational rainfall data and delays in transmitting data from weather stations to UNMA forecasters for analysis. The project worked with UNMA to improve the availability of weather stations for observing daily rainfall data and ensure that weather data is reported to UNMA daily for improving the accuracy of seasonal and ten-day forecasts localized to sub-county level.

Dissemination channels: The communication channels most preferred by farmers were FM radio broadcasts followed by text/SMS messages. The project uses FM radio, mobile phones, community loudspeakers, and face-to-face communications through extension agents for improving farmers' access to climate and agricultural information.

Institutional framework: Effective climate/agricultural information generation, dissemination, and utilization require a combination of innovative technological and institutional arrangements. The project strengthened the institutional arrangements tested during CHAI-pilot at national, district, sub-county, and village levels to support the generation, dissemination, and use of climate/agricultural information. This included formalizing the roles and responsibilities of the District Climate Information Committee (also known as District Environment Committee), regularizing the meeting schedules of the committee, assigning an elected focal person for sub counties and ensuring the participation of extension agents during village-level meetings.

Action Resources: Information delivery using ICT tools alone cannot provide a meaningful contribution to development if the farmers do not have access to resources that will enable them to act on decisions made with the acquired information. The project has identified support agencies with the resources to help farmers transform the acquired knowledge into action ("action resources"). The design of the intervention included mechanisms for linking farmers with support agencies operating locally to enable the farmers to access the resources they need to act on information received through the project. The list of organizations who served as an action resource and the roles they played is provided in **Annex I**.

The description of the major components of the climate/agricultural information system deployed at the intervention districts are provided in the following sub-sections.

Major technology components: this sub-section delineates the major components of the system including mobile technology-based weather and market data collection tools and processes and climate information dissemination platforms.

Institutional adaptation framework: this sub-section outlines the institutional framework used by the project including the roles and responsibilities of the institutions in supporting the generation, dissemination and use of adaptation information.

Adaptation information generation and dissemination: this sub-section details the sources and types of climate/agricultural information disseminated to farmers in the intervention districts.

4.2.1 Major Technology Components

Daily Weather Data Collection and Submission

In Uganda, the availability of limited observational rainfall data is a major impediment to improving the accuracy of forecasts. Working closely with UNMA, the CHAI-II project continued supporting identified and selected sub-counties that were equipped with rain gauges in the three intervention districts (Nakasongola, Soroti, and Sembabule).

During CHAI-pilot, there were only 12 functional rain gauges in Nakasongola, Soroti and Sembabule districts, while the requirement for making sound seasonal forecasts was 22 rain gauges. The CHAI-II project installed 10 new rain gauges at sub-county level in the three districts; these were operational during the period of performance of this project. As the control district, no enhancements were made to the weather stations in Rakai district.

The weather data collection tool developed by the project supports the collection of weather data on mobile devices daily, the transmission of the data via the cellular network to a server installed at UNMA in Kampala, and the export of the data to weather forecast applications used by the Authority's forecasters.

District-based meteorology weather station data recorders based at sub-counties were trained on using mobile phones for collecting and transmitting daily weather data.

Trained weather data recorders collected rainfall data using Samsung Galaxy Ace smartphones provided by the project and transmitted the data to the server installed by the project at the Meteorology Authority in Kampala daily.

The availability of daily rainfall data from sub-counties enabled the Meteorology Authority to continuously correct forecasts generated by different models; produce better seasonal forecasts that are vitally important for the small-holder farmers to take appropriate actions; and generate localized forecasts that are more relevant for the sub-counties.

Livestock and Crop Market Information System

The project continued using the livestock and crop market information system developed during CHAI-i that supports market price data collection using mobile devices and the automatic generation of market reports using the server installed by the project at the Meteorology Authority.

The market data collection application allowed Community Development Officers (CDO) based in sub-counties to gather wholesale and retail livestock and crop market prices from makeshift and permanent outlets using mobile phones.

The CDOs gathered market data weekly or fortnightly depending on when the markets were open. Livestock and crop market data was gathered from 46 market outlets in the intervention districts. The market data collection tool that runs on mobile devices is presented in English and four local languages (Ateso, Luganda, Rululi, and Runyankole).

CDOs are employees of the local governments. The market data collection and reporting system developed by the project were integrated into the routine activities of the CDOs.

Figure 4: Community Development Officer gathering retail market prices (Sembabule District)

The server application includes a web-based dashboard interface to allow for data export, report generation, and visualization. It facilitates real-time data transfer from remotely located mobile devices and the deployment of new and updated data collection forms to mobile devices in the field. A report generation module in the server application automatically generates market reports every week for dissemination to target communities through FM radio, text messaging, email, and community loudspeakers.

Information Dissemination Platforms

SMS Broadcasting

During CHAI-pilot, an information dissemination platform using SMS developed by FHI360 for the project was used. The core SMS broadcasting system was installed on the project server in Kampala. However, to ensure continued local support for the upgrade and maintenance of the system during CHAI-II, the project engaged local bulk SMS providers for content dissemination via text messaging. The project team was responsible for loading content for dissemination to the farmers in the intervention districts via a "we portal" that is exclusive to the project team.

Interactive FM Radio

The project entered into agreements with three local radio stations in the three intervention districts. The selection of the radio stations was made based on the findings of the baseline study that documented the preferred radio station of communities; the times most households tune in to the radio; and their favorite radio programs.

The project aired monthly radio talk-shows that covered the climate information generated for the district. Participants in the talk-shows included district production, NAADS, water, and environment officers; district chairpersons and Chief Administrative Officers (CAO); and/or personnel from the Meteorology Authority and the Climate Change Unit. Moderated by renowned anchors from the three local radio stations (ETOP Radio in Soroti district, Radio Buruli in Nakasongola district, and Radio Mbabule in Sembabule district), the monthly talk shows were designed to be interactive. During the talk shows, farmers were encouraged to call or use text-messaging to ask questions or request clarification. A dedicated multi-team call attendant queued calls in order received. Callers' questions and responses from the talk show participants were aired live to the audience in the district.

In addition, climate and agricultural information was disseminated through a 5-minutes time window every week to reinforce the messages shared through talk shows. Ten-day weather forecasts and advisories based on the forecasts were also aired as part of the agreement with the three radio stations.

Community loudspeakers

The project disseminated climate and agricultural information employed the community loudspeakers that are widely used in urban and semi-urban settings for making public announcements, product advertisements, and announcing private functions such as weddings. Announcements about seasonal forecasts, agricultural advisories, and how to obtain CHAI information through FM radio and mobile devices were made during market days and public gatherings.

Face-to-face community meetings

The delivery of climate and agricultural information was accompanied with face-to-face meetings between extension agents and farmers. The extension agents received the same set of information provided guidance through participatory discussions with farmers at each village. The full content of climate and agricultural information was posted in community bulletin boards and used by extension agents to guide face-to-face discussions with farmers. The meetings were held at the village level where all farmers are invited to attend. The frequency of the meetings varied between every two weeks during rainy season, to every month before planting season. The meetings enabled extension agents to reach many people and explain how the farmers can access climate and agricultural information via mobile phones and interactive radio programs.

4.2.2 Institutional Framework

Effective climate and agricultural information generation, dissemination, and utilization require a combination of innovative technological and institutional arrangements. The project used an elaborate institutional arrangement to support the generation, dissemination, and use of climate information for the intervention district.

Integrating the weather and market data management at the district and national levels was critical for the sustainability of the efforts and derived benefits of the project. The weather and market data collectors trained on mobile data collection were staff from the UNMA and the local (district) Governments respectively.

The generation of climate/agricultural information has been mainstreamed into the business processes of pertinent institutions such as UNMA and district-based farmer support agencies such as Production, Water, Natural Resources Management, Community Development, Commerce, and Communications Departments.

4.2.3 Climate and Agricultural Information Generation

The institutional arrangement illustrated above guided the generation and dissemination of climate and agricultural information to the farmers. Brief descriptions of the adaptation information generated, and the approaches used by the project for generating it are provided below.

Location-specific seasonal and ten-day weather forecasts
Weather recorders from 22 sub-counties of the three intervention districts collected and transmitted rainfall data daily. The availability of daily rainfall data from sub-counties enabled the UNMA to generate timely and more accurate forecasts by continuously correcting estimates generated by different models.

Seasonal (three-month duration) and ten-day weather forecasts were sent to members of the intervention districts' Climate Information Committees. The members of the District Climate Information Committee include the Production Officer, Water Officer, Commercial Officer, Natural Resources/Environment Officer, Commercial Officer, Community Development Officer, Communications Officer, District Chairperson, and Chief Administrative Officer.

Working with the UNMA, the project trained the district teams on how to generate agricultural advisories from seasonal and ten-day forecasts. Based on the training they received, the district team generated agricultural advisories for each sub-county in their district. The agricultural advisories included information on what types of crop to plant and where to get the seeds, how to protect plants from extreme heat and pests, weed management, and harvest and post-harvest crop management.

Climate-based agricultural advisories

The Uganda National Meteorological Authority (UNMA), a key partner of the project, was responsible for generating climate-based agricultural advisories such as crop planning advice (crop varieties suitable for the season, sowing/harvesting times, and other crop husbandry operations); crop management advice based on updated weather forecasts and how it will affect sowing, weed management, pest and disease incidence and control, harvest and post-harvest handling of crops; and crop and livestock management under unfavorable weather conditions such as heavy rains, floods, and strong winds. The advisories were generated for each sub-county in the intervention districts. The advisories were sent to members of the intervention districts' Climate Information Committees. The members of District Climate Information Committees included Production Officers, Water Officers, Commercial Officers, Natural Resources/Environment Officers, Commercial Officers, Community Development Officers, Communications Officers, District Chairpersons, and Chief Administrative Officers. The district Production Officer adapted the advisories to local languages and settings. The localized advisories were broadcast via interactive FM radio transmissions where farmers are encouraged to call or use text-messaging to ask questions or request for clarification. A dedicated multi-team call attendant queued calls in order received and callers' questions and the responses to them will be aired live. Summarized version of the advisories was disseminated via text messages to individuals who use mobile phones. The full content of the advisories was also be posted in community bulletin boards and used by extension agents to guide face-to-face discussions with community members.

Crop and livestock market information

Working with the district-level local government, the project collected livestock and crop market prices from 46 market outlets in the three intervention districts. CDOs based at the sub-counties gather livestock and crop market prices from assembly and permanent market outlets, collecting wholesale and retail prices using mobile phones. The CDOs are employees of the local government, and the market data collection and reporting system developed by the project are integrated into the routine activities of the CDOs. Weekly market information was transmitted via local FM radio stations and posted on community bulletin boards. A summary of the weekly market information was sent via text messaging to community members who use mobile phones.

Rain water harvesting techniques

Working with water and production officers in the intervention districts, the project generated guidance on low-cost water harvesting techniques including the design, cost, operation and maintenance of such systems and suggested uses for the harvested water.

Termite control

Termites that feed on live plants and organic matter and that cause significant damage to crop, seedlings, grass, trees, wood fence pickets, and wood houses are a major problem in Nakasongola district. Termites' foraging activity in this district is intensified during water stress. The project worked with Nakasongola district Production Officer to generate termite control information.

Climate and Agricultural Information Recipients

Scale and reach

Based on the estimates provided by the three participating radio stations, climate and agricultural information reached **over 250,000 farmers** in the three districts.

SMS broadcast targeted specific individual farmers who provided their phone numbers during baseline and midline data collection, farmer groups, community leaders, district technical officers, and politicians from local councils.

The farmer groups served as an important interface between the project and individual farmers for sharing adaptation information and knowledge. The project identified **104 farmers groups** in the three districts and disseminated climate and agricultural information through text messaging to the groups. The farmers groups are primarily organized along the following main themes: coffee farmers group, cattle keepers group, food crop farmers group (farmers growing beans, maize, bananas, sorghum, etc.), and fruit tree farmers group. The average member size of the groups is about 50 farmers. Climate/agricultural information received by group members via mobile phones is shared with group members and discussed during group meetings.

District officers, political leaders, and technical personnel received climate/agricultural information via email and text messaging. Information recipients in these categories include:

- Council members at district, county and sub-county levels;
- District technical team (including, but not limited to, technical personnel working for the Production, Water, Environment, Commerce, Communications and Community Developments);
- Market and weather data collectors; and
- Religious and community leaders.

Addressing farmer's feedback

The climate and agricultural information system deployed by the project included a mechanism for receiving feedback from farmers to ensure that farmers' information needs are met. Farmers provided feedback on the ease of access, understandability and usefulness of information, language preferences, preferred communication channels, the preferred timing of radio talk shows and messages, and additional information needs. Feedback from farmers were received through text messages, phone calls during radio talk shows, during village-level face-to-face meetings and household surveys. Feedback from farmers was used for the additional localization of content and respond to the specific information needs and preferences of farmers.

4.3 Study Design

A comparative pre- and post-intervention design was used to study the impact of ICT-mediated climate information dissemination in increasing access to relevant information and minimizing crop loss and damage sustained due to the impacts of climatic hazards, and communities' willingness and ability to pay for climate information services. Three intervention districts (Nakasongola, Sembabule, and Soroti) received climate information through the project, while the fourth district (Rakai) served as the comparison district.

The study involved the collection of data at two points. The first wave (wave-1) of data collection was conducted in September 2016, and the second wave (wave-2) was conducted in September 2017.

Both wave-1 and wave-2 involved a household survey, focus group discussions, and key informant interviews to assess if the adaptive capacity of the households in the intervention districts had improved because of receiving and using the information disseminated by the project. The study compared intervention districts and the comparison district of Rakai using the following indicators:

- Access to adaptation information;
- Minimization of crop loss and damage due to the major water-related impacts experienced by the communities.

A **Total Cost of Ownership (TCO)** analysis was conducted to determine the costs involved in the generation and dissemination of climate information and the provision of support to communities to help them apply information in action. The cost determination using TCO included the costs associated with the current level of operations of the system and the costs associated when system is expanded to additional districts.

Detailed descriptions of the findings of the studies are provided in subsequent sections.

4.4 Sample Design

4.4.1 Selection of Study Districts

The research activities of the project were carried out in the CHAI-pilot districts of Soroti, Nakasongola, and Sembabule (intervention) and Rakai (comparison) districts. A purposive sampling was used to select districts that could represent the overall characteristics of the cattle-corridor. The selection was made in close consultation with the Climate Change Department, Wetlands Management and the Uganda National Meteorological Authority (UNMA) of the Ministry of Water and Environment, and researchers from Makerere University. Selection criteria include the following.

Districts experiencing water stress: The selected districts lie in the cattle corridor which constitutes one of the most fragile areas in the country and where climate change induced water challenges are evident.

Districts lying in different Water Management Zones: To facilitate sustainable and integrated water resources management, MWE divided the country into four Water Management Zones delineated by topography, drainage demand patterns, water stress, and potential water conflicts in each zone. The four Water Management Zones are: Kyoga (Eastern), Victoria (Central), Albert (Western), and the Upper Nile (Northern) Zones. The selected districts lie in two water management zones. Soroti and Nakasongola are in the Lake Kyoga zone, Rakai and Sembabule are in the Lake Victoria zones. These zones are characterized by severe water stress. The other two water management zones are outside of the cattle corridor.

Districts overlapping with NAPA study sites: Nakasongola, Soroti, and Rakai are among the twelve districts where climate-related data was gathered for the preparation of the Uganda National Adaptation Programs of Action (NAPA) which is the basis for responding to immediate and urgent adaptation needs.

The selected districts represent a range of water management, hydro-climatic, climatologic, and agro-ecological conditions. This diversity ensured that the research was undertaken in diverse settings making findings of the research more representative of the national situation.

Based on the above criteria, Soroti, Nakasongola, and Sembabule were selected as the intervention districts. Rakai, which shares similar biophysical and socio-economic characteristics to the intervention districts, was used as the control to compare the impact of the interventions. Pilot district locations are shown in the following map (**Figure 1**).

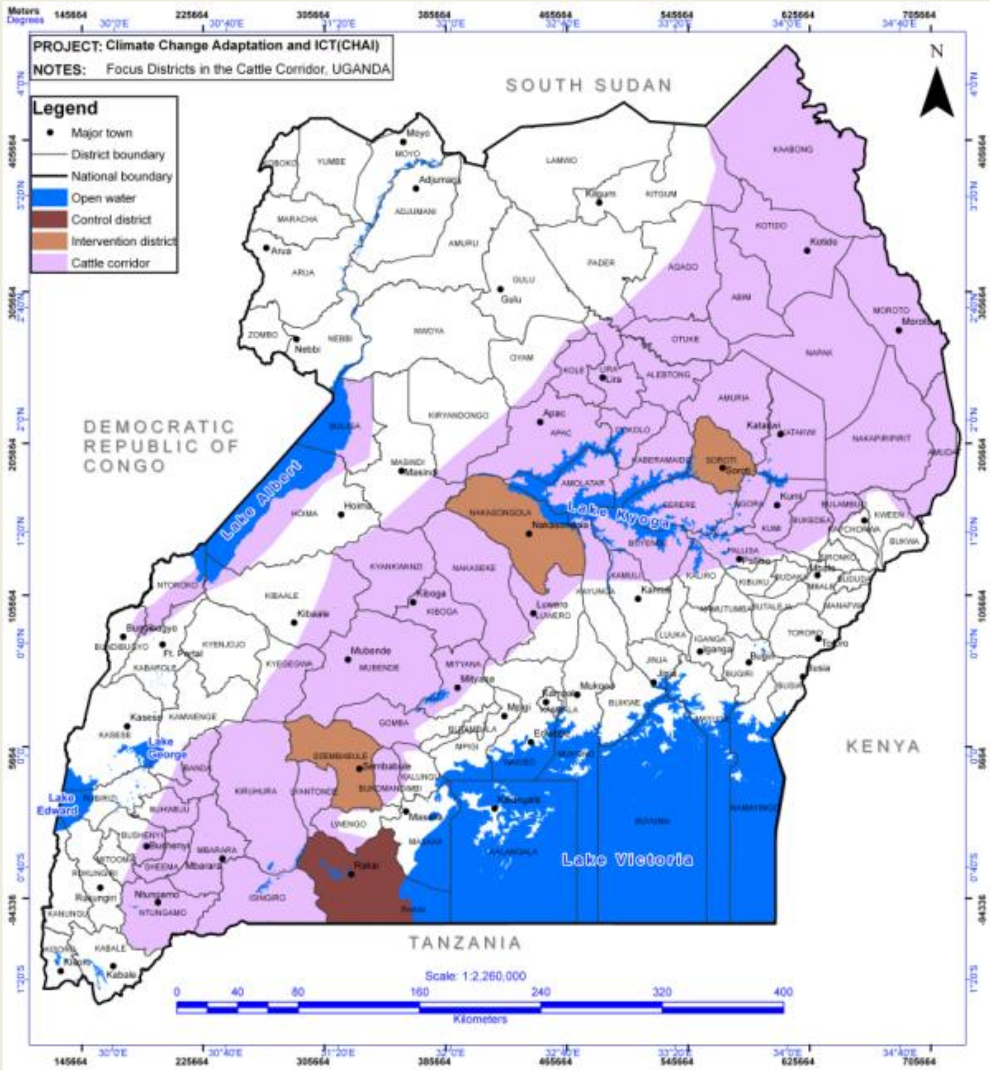

Figure 5 CHAI intervention and control districts.

4.4.2 Data Type and Sources

Quantitative Survey

The quantitative study involved household surveys conducted at two points (September 2016 and September 2017) in Nakasongola, Soroti, Sembabule, and Rakai districts. The studies employed a stratified random sampling design. Sub-counties in the study districts were first classified into two strata: predominantly livestock and predominantly crop agriculture-based livelihoods. For each stratum in every district, a sub-county was randomly selected. The parishes in the randomly selected two sub-counties were further classified into predominantly livestock and crop agriculture-based livelihoods. Again, two parishes, one representing livestock and the other crop agriculture, were randomly selected. The villages in the selected parishes were stratified in a similar fashion and two villages from each parish were selected representing livestock and crop-based livelihoods.

The progressive stratification of the clusters (sub-counties, parishes, and villages) into livestock and crop agriculture-based livelihoods enabled the delineation of a representative sampling unit. A total of 34 villages[3], 8 from each district, were selected using this sampling approach. For gender consideration, at least 25% of the household heads interviewed per village were female.

Random selection of the households was made in accordance to the following procedure:

- In close consultation with the village local council, the center of the village was identified.
- At the center of the village, a pen was spun clockwise and the direction where the pen pointed was followed.
- From the center of the village, every third household head aged 18 and above was interviewed until the 20 households were attained. Where the household head was not available, the next household was interviewed.

The first wave of the survey covered a sample of 644 households of which 163 (25.3%) were in Nakasongola, 161 (25%) were in Soroti, 160 (24.8%) were in Sembabule, and 160 (24.8%) were in Rakai district.

For the second wave of the survey, the sample size was increased to 813 households of which 180 (22.1%) were in Nakasongola, 183 (22.5%) were in Soroti, 228 (28%) were in Sembabule, and 222 (27.3%) were in Rakai district. The increase in the total sample to 813 households was made to account for sampling and no-sampling errors including non-responses.

A panel study that measures the same variables in the same group of household heads at the two time-points of the survey was envisaged. However, sample attrition[4] primarily caused by the mobility of the respondents and the inability to locate the current dwelling of the sample hindered to interview the same individuals. In addition to geographic mobility of the respondents, sickness, death and in some cases refusal to participate in the 2nd survey were the additional reasons for sample attrition. As a result, over 80% of the respondents of the 2nd survey included randomly selected households from the same village as the 1st survey respondents.

[3] The sample design included 32 villages. However, during the baseline survey, it was found that two villages didn't have adequate number of households meeting the sample criteria. The study team filled in the missing households from neighboring villages.

[4] Sample attrition is the loss of sample during the course of a study.

Sample attrition is one of the inherent challenges faced by any longitudinal household survey. Attrition in household surveys can come from deaths, refusals, inability to locate the baseline dwelling (due to insufficient information about the location), and migration

Qualitative Data

The qualitative study involved semi-structured key informant interviews (KII) and focus group discussions (FDG). Purposive sampling was applied, and data was collected until saturation or when the point was reached at which no new theme or information emerged from the respondents.

The purpose of the key informant interviews was to gather information from a range of people with first-hand knowledge about the community, its climate information needs, how climate information is used, the factors impeding the effective use of information, usefulness of information received, and how the system can be improved. The study identified and selected key informants from the Civil Society Organizations (CSOs) and Non-Government Organizations (NGOs) operating within the community; district and sub-county leaders (Community Development Officers, Probation Officers, and LC1 chairpersons).

The purpose of the FDG was to understand the respondent's attitudes, experiences, feelings, and reactions to the use of the climate information, including opinions on its benefits, the impediments to applying information in action, and how the system can be improved to better serve the needs of small holder farmers. The FGDs were guided by a moderator allowing the participants to discuss, agree, or disagree with each other to better understand what the discussants think about the climate information system and its value in minimizing the risks imposed by climatic hazards.

The focus groups were constituted with 2 members of the zone leaders, 2 persons from the Local Council 1 (LCI) committee, a woman representative, a youth representative, an opinion leader, a representative of persons with disability, a representative of the refugee households. Sixteen FGDs focus discussions were conducted – four per district; two for men and two for women. All FDG participants were above 18 years and had not participated in the household interviews. The distribution of FDGs and KIIs by district is provided in the following table.

District	FGDs	KIIs
Nakasongola	4	5
Rakai	4	3
Sembabule	4	7
Soroti	4	4
Total	**16**	**19**

Table 1: Number of key informant interviews and focus group discussions by district

Questionnaire and Discussion Guide Development

The quantitative questionnaire and the qualitative discussion guide applied in the study were developed to collect data from respondents. The structured questionnaire for household survey and semi-structured discussion guide for focus group discussions and key informant interviews were field-tested and approved by the Uganda National Council for Science and Technology (UNCST) prior to use.

The household surveys were designed to determine the hazards affecting the communities, the impacts of the hazards on the livelihood and wellbeing of the communities, and the changes in the adaptive capacity of the communities as a result of receiving and using the information disseminated by the project. To study if the adaptive capacity of the households in the intervention districts had improved, the study team compared intervention districts and the control district of Rakai using the following indicators:

- Access to adaptation information;
- Usefulness of received adaptation information for coping with hazards;
- Adaptation actions taken by communities;
- Effectiveness of the adaptation actions taken based on information they received; and
- Minimization of crop and livestock loss and damage due to the major climate-related impacts experienced by the communities.

Data Collection

The household surveys were conducted using Samsung Galaxy smartphones equipped with Global Positioning System (GPS) for capturing geographic coordinates of the responding households. Data collection for the first wave of the survey was conducted over a period of two weeks (September 15 – 30, 2016); the field data collection for the second wave of the household survey was conducted September 15 – 30, 2017. A total of 18 data collectors for the first and second wave of the survey were recruited and trained for two days on administering the survey using mobile phones. A survey protocol and training manual were developed to guide the training and data collection processes. A pretest of the survey instrument was done on the second day of the training in Wakiso district and data analyzed to check for validity and consistency.

The survey instruments were translated into four local languages: Luganda, Ruruli, Ateso, and Runyankole. In addition to experience and skill, knowledge of local customs and language were used as additional selection criteria for the recruitment of data collectors. The trained data collectors were organized into four groups according to their knowledge of the language(s) spoken in the study districts. A researcher from one of the partnering institutions was assigned to lead the quantitative data collection process at each of the study districts.

Focus group discussions and in-depth interviews with key informants were tape-recorded. Focus group and in-depth interviews were conducted by researchers from the partnering institutions.

Other Data Sources

The study involved the determination of the Total Cost of Ownership (TCO) for the generation and dissemination of climate and agricultural information and the financial requirements needed for rolling out the solution nationwide. The TCO determination was based on information gathered from several sources to determine the costs related to training, text messaging, FM radio broadcasts, equipment, and user support. Data sources included accounting records of the CHAI project; payroll information obtained from UNMA and district-based departments; and established rates by mobile network operators, bulk SMS providers, and FM radio stations. Uganda's 2017 estimated population was obtained from a World Bank publication. Population growth rate and average household size were obtained from the Uganda Bureau of Statistics (UBOS). The number of unique mobile subscribers and the unique subscriber growth rate in Uganda were obtained from the GSM Association (GSMA).

4.4.3 Data Analysis

Household Survey Analysis

Household survey data that was gathered using smartphones was transmitted to a server installed at UNMA in Kampala through the cellular network. The researchers accessed the datasets stored in the server in real time via the Internet and monitored data quality through the data collection process. Household survey data from the server was exported into SPSS version 21, a statistical analysis software.

Examination of the household survey data began with a descriptive analysis of the study districts data. Bivariant analysis of the data (cross-tabs, comparison of means, chi-square test) was then conducted for identifying patterns of association of the elements that are being assessed with the locations of the study areas (district, sub-count, parish, and village).

Qualitative Data Analysis

Transcribed data from audio recordings of focus group discussions and in-depth interviews were analyzed using Atlas.ti version 6.2, a qualitative data analysis and research software developed to analyze interviews, field notes, and other types of textual data. Analysis involved identifying themes, coding the themes/data, organizing the themes into coherent categories, and identifying relationships and contrasting ideas that emerge.

Total Cost of Ownership

The analysis of TCO was conducted to determine the total cost for the current operational level (i.e., the three intervention districts) and the cost per district if the system were deployed nationwide. The TCO was modelled for five years of operation. Detailed TCO analysis is provided under “**5.6.1 Financial Sustainability**” section of this report.

5. Research Findings

As noted in previous sections, the project team conducted two waves of household surveys to gather data on the ICT-based climate adaptation information system developed and deployed by the project to enhance the adaptive capacity of individuals and communities in Nakasongola, Sembabule and Soroti, the intervention districts, and, for comparison, in Rakai, the control district. The first wave of the study was conducted in September 2016, and the second wave was conducted in September 2017. This data was used to analyze and describe the outcomes of the CHAI system.

The following sub-sections provide further details related to the findings of the first and second wave of the study and outcomes of a Total Cost of Ownership (TCO) assessment.

5.1 Sample Characteristics

5.1.1 Household Characteristics

The first wave and second wave surveys covered a sample of 644 and 813 households respectively. The distribution of the respondents by district is provided in **Table 2**.

District	# of Households 1st wave	# of Households 2nd wave
Nakasongola	163 (25.3% of total)	180 (22.1% of total)
Sembabule	160 (24.8%)	228 (28%)
Soroti	161 (25%)	183 (22.5%)
Rakai	160 (24.8%)	222 (27.3%)
TOTAL Sample	644 (100%)	813 (100%)

Table 2: Number of surveyed households during the 1st and 2nd wave by district

The majority (54%) of the household heads during the first wave were aged between 35 and 54 years. The respondents were also mostly married; a few were co-habiting or widowed. Household members were largely young; about 55% were below 23 years of age. The respondents had basic education with at least primary level education. One in three respondents had up to upper primary level education. Farming was the primary occupation of the respondents (88%), followed by livestock rearing (5%); a small number were in engaged in small business and trading (2%). Respondents from Nakasongola district had the highest percentage of livestock rearing as an occupation (15%) followed by Sembabule (4%).

Both surveys found the average household size was 6.7 members, but with significant variations across districts ($p<0.05$). Soroti had the highest average household size (7.7) with Rakai recording the lowest (6.2). Overall, household size in the study districts was higher than the national average (4.7).

During the second wave of the survey, the sampled households across the study districts generally demonstrate a young population (Table 3). Children (0-17 years) constituted about 62% of the total population; those of the primary school age (6-12 years) constituted about 25%. Tthe economically viable and productive population (18-60 years) constituted 35% of the population with above 60 years constituting about 3%.

		Soroti	Rakai	Nakasongola	Sembabule	Average
Household population by sex (%)	Male	48.2	48.7	52.0	49.4	49.5
	Female	51.8	51.3	48.0	50.6	50.5
Household population by age groups (Years) %	0-5	22.5	26.2	21.7	22.7	23.3
	6-12	22.5	25.3	27.3	24.2	24.8
	13-17	14.0	12.5	14.5	15.1	14.0
	18-60	37.6	33.0	33.9	34.6	34.8
	>60	3.5	3.1	2.5	3.4	3.1
	Total	100.0	100.0	100	100	100
% of population that is 0-17 years		59	64	63.5	62	62.1
Average household size		7.7	6.2	7.2	6.1	6.7
Total members in sampled households		1,389	1,374	1,270	1,386	5,419

Table 3: Household composition and size

The heads of households were on average 45 years old but with significant variation by the sex and study districts. The female heads of households were significantly older than their male counterparts (male =43 years, females=47 years, p=.005). The heads of households in Soroti recorded the highest average age while Nakasongola recorded the lowest (Soroti=47 years, Rakai=44 years, Nakasongola=42 years and Sembabule=45 years, p=0.001). Two (0.2%) of the sampled households were headed by children.

Age of the household head by Sex	Soroti	Rakai	Nakasongola	Sembabule	Overall
Male	45.5	43.5	41.6	44.5	43.8
Female	50.9	47.2	45.3	47.1	47.5
Total	47.0	44.4	42.7	45.2	44.8
P	0.034	0.105	0.096	0.233	0.001

Table 4: Average age for the heads of household by study districts and sex of household head

In terms of marital status, at least three quarters (77%) of the heads of household were married, 15% were widowed, 6% had divorced/separated and 3% were never married. The distribution of the heads of household by marital status did not significantly differ across the study districts. However, there were significant variations in the marital status by the sex of heads of households ($p<0.05$) where over 90% of the male heads of households were married, majority of the female heads of households were widowed (49%).

Most of the heads of households across all the study communities were engaged in farming (90%), and 10% in off-farm activities. Nakasongola and Rakai had a relatively high proportion of households engaged in off-farming activities which included fishing (in Rakai) and charcoal making in Nakasongola.

	Study district				Household head gender		Overall
	Soroti	Rakai	Nakasongola	Sembabule	Male	Female	
Marital status of household head							
Married	77.0	74.8	76.1	79.4	94.6	29.1	76.9
Widow/widower	16.4	16.7	11.7	14.0	2.2	48.6	14.8
Divorced/separated	4.9	6.3	8.3	4.4	2.0	16.4	5.9
Not married/Single	1.6	2.3	3.9	2.2	1.2	5.9	2.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Occupation of household head							
Farming	96.7	79.4	85.0	98.6	88.7	93.5	90.0
Salaried employment	1.7	2.8	6.6	1.4	3.5	1.4	2.9
Self-employed off-farm	1.1	3.3	3.0	0.0	1.4	2.8	1.8
Off-farm worker	0.6	6.5	0.0	0.0	2.5	0.5	1.9
Others	0.0	7.9	5.4	0.0	3.9	1.8	3.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N	183	222	180	228	593	220	813

Table 5: Social Demographics of the Heads of Household by District

5.1.2 Quality of life of study communities

The Uganda Bureau of Statistics (UBOS) noted that household characteristics are used in describing the living conditions of households. These characteristics affect the entire household as an entity and hence are useful in guiding policy interventions. Specifically, in the 2014 National Population and Housing Census, UBOS noted that household welfare was a measure of the quality of life of the household members, and the welfare of households was studied with respect to the source of household livelihood, ownership of selected household assets and utilities available to the household (UBOS, 2014). Sections below provide an analysis of some of the key parameters defining the quality of life of study communities.

Sources of energy for lighting and cooking

Studies such as one conducted by the UBOS (UBOS NPHC, 2014) showed that provision of clean alternative energy sources yields benefits by lessening the heavy reliance on wood fuel as the main source of fuel for cooking, hence reducing deforestation and air pollution, and improving household health through reduced exposure to smoke from wood and charcoal, especially for women.

Sources of energy for lighting

Overall, 41% of the households used electricity as the main source of energy for lighting, 38% used paraffin, while 20% used other energy sources including batteries and torches. However, the energy sources for lighting significantly differed across the study districts ($p<0.05$). Use of batteries or torches was commonly reported in Soroti district while solar electricity was the leading energy source reported by households in Nakasongola district (61%). Most of the households in Rakai on the other hand used paraffin (65%). Sembabule had almost equal distribution between solar energy (47%) and paraffin (45%). A relatively higher proportion of the male-headed households than the female-headed households used electricity as the main source of energy for lighting (male-headed=43%, female=38%). These findings are reflected in Table 6.

Main source of energy for lighting	District				Household head sex		Overall
	Soroti	Rakai	Nakasongola	Sembabule	Male	Female	
Electricity (All forms)	***19.7***	***34.2***	***60.6***	***50***	***42.5***	***37.8***	***41.2***
Solar electricity	18.6	30.6	60.6	46.9	40.1	36.4	39.1
Grid (Hydro)	1.1	3.6	0.0	3.1	2.4	1.4	2.1
Paraffin (All forms)	***8.8***	***64.8***	***23.9***	***45.2***	***36.6***	***40.5***	***37.7***
Lantern	4.4	28.8	2.8	30.7	17.7	19.1	18.1
Tadooba (kerosene lamp)	4.4	36	21.1	14.5	18.9	21.4	19.6
Others	***71.5***	***1***	***15.6***	***4.8***	***20.9***	***21.9***	***21.1***
Batteries/Dry cells/Torch	69.4	0.5	12.8	3.9	19.4	20.5	19.7
Candles	0.5	0.5	2.2	0.0	0.8	0.5	0.7
Others	1.6	0.0	0.6	0.9	0.7	0.9	0.7
Total	100	100	100	100	100	100	100

Table 6: Main sources of energy for lighting

Sources of energy for cooking

Results across the study districts indicate high reliance on firewood (93%) and charcoal (7%) as the source of energy for cooking. The proportion of households that used paraffin was highest in the female-headed households in comparison with the male-headed households. None of the households reported using energy sources such as electricity or gas for cooking.

Over reliance on wood fuel not only affects the forest cover leading to adverse negative climate changes, but it also negatively affects the health of the population especially that of women exposured to smoke from wood fuels used for cooking. About 95% of the households used the traditional three stone fire (Table 7), which leads to 85% to 90% loss in energy to the environment outside the cooking pot. This calls in for the promotion of alternative energy saving sources.

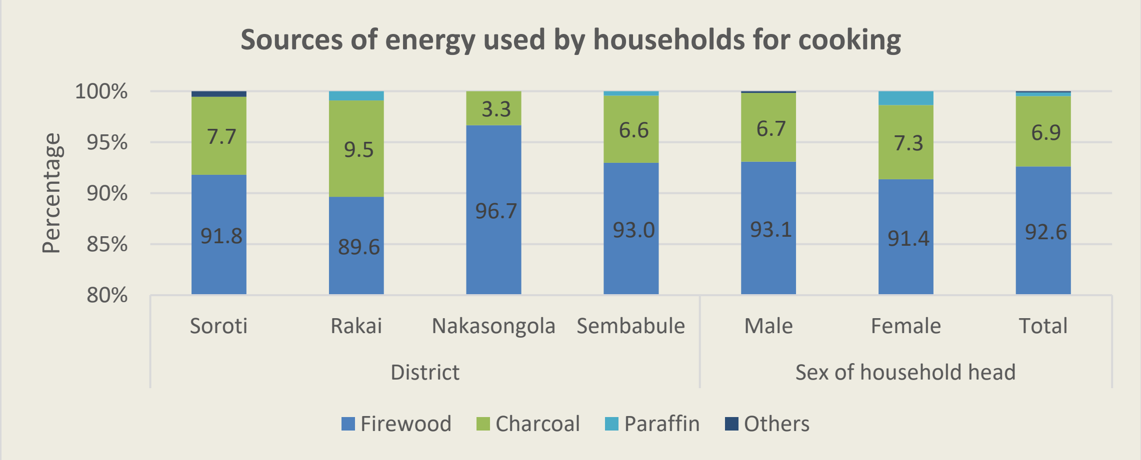

Figure 6: Main sources of energy for cooking

Main source of energy for cooking	Soroti	Rakai	Nakasongola	Sembabule	Overall
Three stones	97.3	93.2	97.8	92.5	95.0
Open charcoal stove (sigiri)	0.0	6.3	1.7	5.3	3.6
Improved stoves (charcoal/ firewood/gas)	2.7	0.5	0.6	2.2	1.5

Table 7: Cooking technology used by surveyed households

Sources of Water for Drinking and Agricultural Use

Sources of drinking water

The sources of drinking water vary greatly by season and across districts (Table 8). There was no significant variations between the male and female-headed households (p>0.05).

Regardless of whether it was rainy or dry season, Soroti had the highest proportion of households that had drinking water from improved drinking water sources with Rakai recording the lowest (see Table 8). The majority (>90%) of households in Soroti used boreholes as the main source of drinking water during the rainy and dry seasons. On the other hand, relatively high proportions of households in Rakai, Nakasongola and Sembabule harvested rain water during the wet season and utilized boreholes or unimproved water sources during the dry season.

Overall, only 73% of the sampled households used improved water sources during the dry season as compared to 85% during the rainy season.

	Soroti	Rakai	Nakasongla	Sembabule	Overall	Male	Female
Wet season							
Protected water source	*100.0*	*78.4*	*80.0*	*84.2*	*85.2*	*84.3*	*87.7*
Protected Spring	0.5	22.1	9.4	7.5	10.3	10.5	10
Hand pump/ Borehole	94.0	0.9	39.4	0.4	30.3	28.8	34.1
Rainwater/harvested water	1.1	46.8	13.9	49.6	30	30	30
Piped water	4.4	8.6	17.2	26.8	14.6	15	13.6
Unimproved water source	0.0	21.6	20	15.8	14.8	15.7	12.3
Dry season							
Protected water source	*98.9*	*54.5*	*68.9*	*73.7*	*73.1*	*71.2*	*78.2*
Protected Spring	2.7	28.8	6.1	13.2	13.5	13.2	14.5
Hand pump/ Borehole	90.7	4.5	41.7	4.8	32.2	30.7	36.4
Rainwater/harvested water	1.1	1.4	1.1	1.8	1.4	1.5	0.9
Piped water	4.4	19.8	20	53.9	26	25.8	26.4
Unimproved water source	1.1	45.5	31.1	26.3	26.9	28.8	21.8

Table 8: Sources of Drinking water

Source of water for agricultural (crop/livestock) during the dry season

Respondents were asked the main sources of water that they used for agricultural activities (crop and livestock production) during dry seasons. Results presented in Table 9 show that the common sources of water for agricultural related activities included piped water (22%), local swamps (18%), boreholes (14%), stream/lake/river (13%), protected well/spring (10%), dams/water reservoirs (9%) and unprotected spring (1%). About 13% did not use water for agricultural purposes during the dry season, relying only on rain water.

Most sampled households in Soroti used water from swamps or boreholes for their agricultural related activities. In Nakasongola, the sources included borehole, piped water, dams and lake/river/stream. The households in Sembabule mainly used piped water, protected springs and dams. In Rakai, water sources included piped/tap water, lakes/river/stream, protected springs/wells and local swamps.

Water Source	Soroti	Rakai	Nakasongola	Sembabule	Overall
Piped water	7.1	23.9	23.9	31.1	22.1
Local swamp	53.0	13.5	2.8	7.0	18.2
Hand pump/ Borehole	31.7	4.1	27.8	0.4	14.5
Lake/River/ stream	6.6	27.5	11.7	4.8	12.9
Protected spring/well	0.0	18.9	5.0	11.8	9.6

Dam	0.0	0.0	23.9	12.7	8.9
Unprotected well/spring	0.0	0.5	1.1	0.4	0.5
None	1.6	11.7	3.9	31.6	13.3

Table 9: Sources of water for crop and livestock during dry seasons

Diseases affecting household members

The health status of the population greatly affects its productivity. At the household level, large sums of money can be spent on treatment for household members who fall sick. Overall, results presented in Table 10 show that across the study districts, malaria was the leading disease (54%) followed by airborne infections such as cough/flue (13%) and water borne diseases such as diarrhea and typhoid (13%).

Diseases affecting household members	Soroti	Rakai	Nakasongola	Sembabule	Average
Malaria	59.5	49.7	48.8	58.8	54.3
Air borne (Cough and Flu)	11.5	6.2	22.4	14.2	13.1
Water borne (Diarrhea and Typhoid	14.0	16.9	4.8	13.5	12.6
Body Pains and Disorders	3.6	1.6	2.0	2.1	2.3
Cholera	0.0	7.1	0.0	0.3	2.0
Measles	5.7	0.0	2.4	0.0	2.0
Pressure	1.4	0.6	1.2	0.3	0.9
Ulcers	0.4	0.3	1.6	0.3	0.6
Others	2.2	1.0	3.2	1.0	1.8
None	1.8	16.6	13.6	9.3	10.4

Table 10: Common diseases affecting health status of households

5.2 Access to Agricultural Land

5.2.1 Acreage for Agricultural Activities

Table 11 shows the proportion of households that had access to agricultural land, and the amount of land that was used for agricultural activities. On average, the households had access to three acres of land but with significant variation across the study districts ($p<0.05$) and between male and female-headed households ($p<0.05$). Nakasongola recorded the highest average agricultural land acreage (4.5 acres) while Rakai recorded the lowest (2.3 acres). Households in Soroti and Sembabule had an average size of 3.3 acres and 2.6 acres respectively. The male-headed household had on average 3.3 acres of land while their female counterparts had 2.6 acres of land.

	District					Sex of household head	
Land size (acres)	Soroti	Rakai	Nakasongola	Sembabule	Overall	Male	Female
None	0.0	1.4	4.4	0.4	1.5	1.0	2.7
<=1	10.9	35.1	4.4	27.6	20.8	19.4	24.5
<=2	31.1	21.2	8.9	20.2	20.4	19.2	23.6
<=3	19.7	15.8	11.1	19.7	16.7	16.2	18.2
<=4	12.0	6.3	12.8	11.0	10.3	11.1	8.2
<=5	10.4	5.0	10.0	4.4	7.1	7.3	6.8
<=10	13.7	9.5	21.1	8.3	12.7	14.8	6.8
>10	2.2	5.9	27.2	8.3	10.5	11.0	9.1
Average total size	3.3	2.3	4.5	2.6	3.0	3.1	2.6

Table 11: Land Acreage accessed by the households

5.2.2 Ownership of the Land Parcel

For effective decision making on land usability, it is important that those having access to it have full control and ownership over it. However, it is common practice in Uganda for land owners to bar tenants from using land for some agricultural activities, especially those involving permanent or long-term establishments such as irrigation infrastructure or the planting of fruit trees.

The average household has land acreage spread in two parcels. The majority of these land parcels are freehold with no land titles (79%). The nature of land ownership had no significant correlation with the sex of the heads of households ($p>0.05$). However, the nature of land ownership varied by study district. The parcels to which households had land titles were mainly in Nakasongola and Sembabule (Table 12).

	Study district				Sex of household sex		
	Soroti	Rakai	Nakasongola	Sembabule	Male	Female	Overall
Total number of parcels	460	371	203	354	1,048	340	1388
Ownership of land parcels (%)							
Freehold without title	99.8	74.7	54.7	68.6	78.7	77.9	78.5
Freehold with title	0.0	5.1	29.6	14.4	9.4	9.1	9.4
Rented from other individuals	0.2	14.3	2.0	14.1	7.4	8.8	7.8
Not owned	0.0	5.1	10.8	1.7	3.4	3.2	3.4
Communal	0.0	0.5	2.5	0.0	0.5	0.6	0.5
Mailo land tenure[5]	0.0	0.3	0.5	1.1	0.5	0.3	0.4

[5] Under Mailo land tenure, land is registered and owned in eternity or perpetuity with its holder having a land title for it.

Table 12: Ownership of land parcels

5.2.3 Acquisition of land parcels for agricultural activities

Table 13 shows mode of land acquisition by household for agricultural activities. Land is either purchased, inherited, rented or owned by an external entity such as government. The mode of acquisition of the land parcels used for agricultural purposes significantly differed across study districts.

Most land in Soroti was inherited (83%) or purchased (16%) while in Sembabule, Rakai and Nakasongola mixture of purchase, inherited and rented land parcels. Government or institutional land was more prevalent in Sembabule than in the other study districts.

Mode of acquisition (%)	Soroti	Rakai	Nakasongola	Sembabule	Male	Female	Overall
Purchased	15.9	57.7	41.4	69.2	45.3	41.5	44.4
Inherited	83.3	21.3	34.0	13.3	41.3	42.6	41.6
Rented	0.4	15.4	3.0	16.1	8.4	10.0	8.8
Others (e.g. government/reserved land)	0.4	5.7	21.7	1.4	5.0	5.9	5.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 13: Mode of acquisition for the land parcels used for agricultural purposes

Land hire was more pronounced in the districts of Rakai and Sembabule. Overall, about 16% of the households had hired land during the reference season with the lowest number of households hiring land observed in Nakasongola (2%) and the highest in Sembabule (24%) and Rakai (23%). The households that hired land in Soroti during Wave-I constituted about 14%.

5.2.4 Land usage

Land usage defines the nature of activities undertaken on the land parcels that households had access to as at the time of the surveys. Table 14 shows that 86% of the land parcels were used for crop production, 6% for livestock keeping, 7% for homesteads. About 1% of the land parcels were not utilized during the period surveyed.

	Study district				Sex of household head		
	Soroti	Rakai	Nakasongola	Sembabule	Male	Female	Overall
Crop production	77.2	90.3	78.3	92.4	84.6	85.0	84.7
Livestock keeping	5.4	2.2	12.8	6.2	6.3	4.4	5.8
Homestead	15.7	5.1	0.0	0.3	6.5	7.1	6.6
Woodlot/ forestry	0.0	1.1	1.0	0.0	0.5	0.3	0.4
Nothing	1.7	1.1	1.0	0.6	1.0	1.5	1.2

Others	0.0	0.3	6.9	0.6	1.0	1.8	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 14: Main land use on the parcels

5.2.5 Agricultural Land Purchase and Rental Prices

Results presented in **Error! Reference source not found.**15 show the average purchase price for an acre of land in the communities. Overall, an acre of land costs about UGX2,900,000 ($814) to purchase; land is significantly more expensive in Soroti ($1000) and Rakai ($917) than in Nakasongola ($306).

Wave-II		Soroti	Rakai	Nakasongola	Sembabule	Overall
Purchase price (acre)	Mean	$991	$917	$300	$709	$814
	95% CI	$949	$856	$278	$680	$788
		$1,033	$978	$322	$738	$840
Rental price (acre per season in 2016)	Mean	$18	$35	$28	$42	$31
	95% CI	$17	$32	$24	$40	$30
		$19	$37	$31	$44	$33
Rental price (acre per year in 2016)	Mean	$36	$69	$50	$89	$63
	95% CI	$34	$63	$41	$85	$60
		$39	$74	$60	$94	$66
Wave I						
Average hire cost per Acre per season		$20	$13	$17	$19	$17

Table 15: Purchase and hire price for an acre of land

Figure 7 shows an overall rental fee of UGX 237,000 ($66) per year and UGX 113,000 ($31) per season. Uganda has a bimodal rainy season; paying per season is slightly cheaper. Overall, the average rental fees during wave II had almost doubled in comparison with the fees reported during Wave-I. During Wave-I, on average, hiring an acre of land for a season cost UGX 61,000 ($17); costs were relatively lower in Rakai (UGX47,000 or $13) and higher in Soroti (UGX71,000 or $20).

The increase in the rental fees in the districts of Rakai, Nakasongola and Sembabule as compared to Soroti is mainly attributable to the observed increase in market value of land in the region over the last three years.

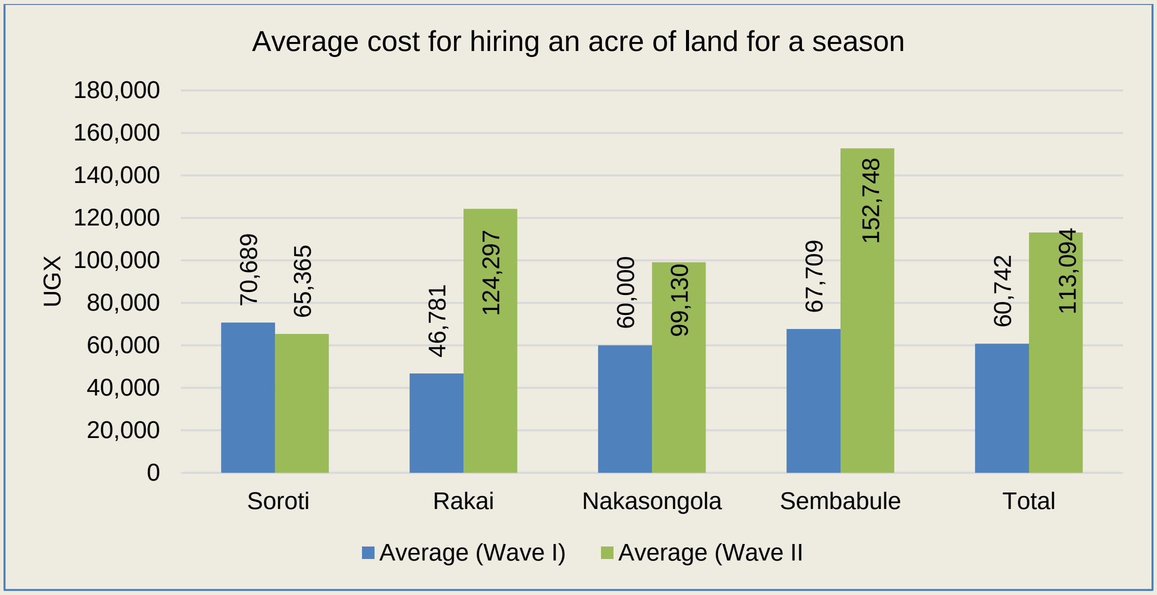

Figure 7: Average cost for hiring an acre of land for a season in Ugandan Shillings (UGX)

5.3 Crop Production

Crop production was the main activity used by the farming households across the study districts. Respondents were asked if their households grew any crops and what crops they had grown during the season preceding the surveys.

Figure 8 shows about 95% of the sampled households across the study districts grew some crops during the referenced season. However, there were significant variations in the proportion of households that grew crops by study districts ($p<0.05$). Nakasangola had the lowest proportion of households that grew crops (89%), and Soroti the highest proportion (100%). The proportion of households that had grown at least one crop during the referenced season did not show significant variation between the male and female-headed households ($p>0.05$).

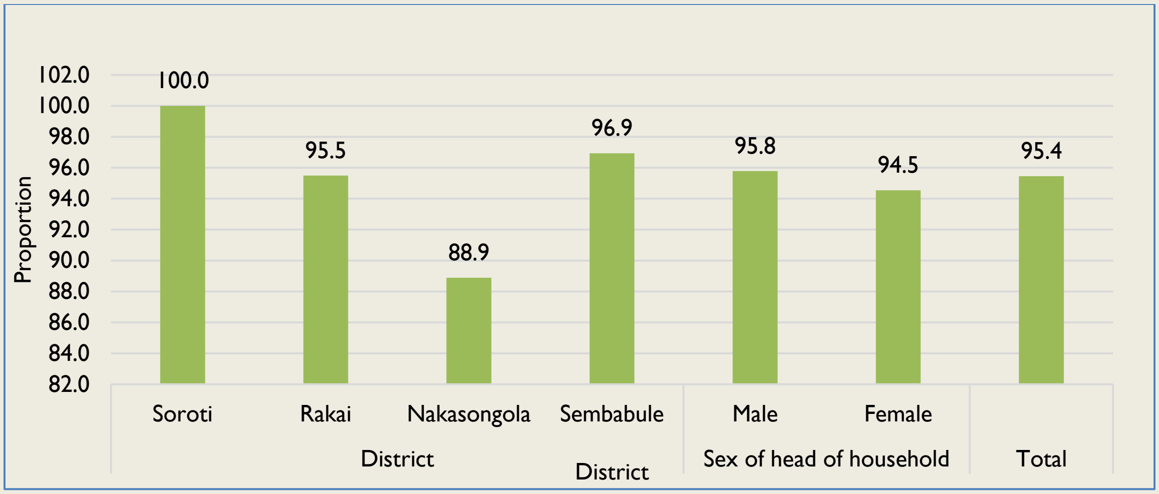

Figure 8: Proportion of households that grew crops previous season

5.3.1 Common crops grown

Data on crops used by households as farm inputs for sowing are provided in the table below. The crops most widely sown are different in each district. In Rakai district, farmers put emphasis on beans (34%) and maize (32%), while the most important crops farmers plant in Nakasongola are maize (34%), sweet potatoes (23%), and cassava (22%); in Sembabule maize (56%) and beans (22%); and in Soroti ground nuts (29%) and cassava (20%).

Crop	*Rakai*	*Nakasongola*	*Sembabule*	*Soroti*	Overall
Maize	31.9	33.9	55.8	6.9	32.4
Beans	34	1.8	26.8	1.5	17.2
Other	4.3	1.8	9.4	9.2	6.4
Bananas	4.3	0	2.2	0	1.7
Coffee	0	0	1.4	0	0.4
Crops	0	0	1.4	0	0.4
Cassava	0	22	0.7	20	9.8
Ground nut	0.7	14.7	0.7	29.2	10.8
Millet	0	2.8	0.7	9.2	3.1
Sweet Potato	2.1	22.9	0.7	10	8.1
Irish Potato	20.6	0	0	0	5.6
Peas	0.7	0	0	3.1	1
Sorghum	0.7	0	0	10.8	2.9
Tomato	0.7	0	0	0	0.2
N =	141	109	138	130	518

Table 16: Major Crops Used as Farm Inputs by District

Results presented in Table 17 show that the common crops grown differed by study communities ($p<0.05$) with maize most common followed by beans (21%), cassava (13%), sweet potatoes (9%), ground nuts (8%) and sorghum (5%).

Cassava, sweet potatoes, sorghum and ground nuts were the most commonly grown crops in Soroti. The most common crops in Rakai were beans, maize and bananas; in Nakasongola, these were maize, cassava, sweet potatoes, and ground nuts; Sembabule mainly produced maize and beans.

Crop Type	Soroti	Rakai	Nakasongola	Sembabule	Overall
Maize	7.0	30.9	25.3	41.9	24.9
Beans	2.7	35.4	6.1	40.5	20.6
Cassava	25.2	2.7	23.8	0.6	13.4
Sweet potatoes	14.6	1.6	22.0	0.2	9.4
Groundnuts	10.0	0.8	19.0	2.8	7.7
Sorghum	17.0	0.2	0.0	0.0	5.4
Bananas	0.0	13.7	0.3	2.3	4.1
Coffee	0.0	2.5	0.0	10.2	3.0
Green grams	8.9	0.0	0.0	0.0	2.8
Irish potatoes	0.0	9.2	0.0	0.0	2.3
Finger millet	5.6	0.2	0.3	0.4	1.9
Cowpeas	3.2	0.4	0.0	0.0	1.1
Pigeon peas	1.7	0.0	0.0	0.0	0.5
Others	4.1	2.3	3.3	1.1	2.8
Total	100.0	100.0	100.0	100.0	100.0
% of total households that grew any crop last season	100%	96%	89%	97%	95%

Table 17: Main crops grown by district

5.3.2 Production per acreage for major crops

Results presented in Table 18 show the average household acreage and average crop production for the most common crops grown by the farmers in the study districts.

Maize: Maize was the most common crop grown by households. During the previous year (2016) prior to the survey date (September 2017), farming households harvested an average of 373 kg of maize. However, there were significant variations across the study districts. The highest average maize production was in Sembabule, the lowest in Soroti (206 kg). Overall, there was an average production of 285kg of maize per acre.

Beans: Households harvested an average of 243 kg of beans in 2016 with an overall average production of 169 kg per acre. Rakai had the highest production of beans among the study districts, averaging 226.2 kg per household and 171.4 kg per acre.

Cassava: On average, the households harvested 469.7 kg of cassava per acre in 2016. Cassava production was highest in Soroti followed by Nakasongola.

Sweet potatoes: On average, 320 kg were harvested per acre and 336 kg per household. However, sweet potato production differed by study districts with Nakasongola and Soroti recording the highest average productions.

	District	Maize	Beans	Cassava	Sweet Potatoes
Average household acreage	Soroti	0.9	0.8*	1.1	0.8
	Rakai	2.1	2.1	1.7	1.3
	Nakasongola	1.9	1.3	1.5	1.1
	Sembabule	2.4	2	1.2	1
	Total	2.1	2	1.2	0.9
Average household yield (kg)	Soroti	206.8	187.5	501.5	287.8
	Rakai	304.4	226.2	75*	333.3*
	Nakasongola	336.1	93.2	359.5	390
	Sembabule	475	267.8	150*	300*
	Total	372.9	242.5	365.7	336.2
Average production per acre (in kg)	**Soroti**	232.9	312.5*	522.3	323.7
	Rakai	244.4	171.4	400.1*	100.0*
	Nakasongola	288.2	84.1	316.6	326.6
	Sembabule	321.4	167.4	250.0*	300.0*
	Total	285	168.6	469.7	319.8

Table 18: Average crop production per household (*fewer than five households harvested the crop)

5.3.3 Total acreage under crop production

Study participants were asked to indicate the total number of acres of land they allocated for crop production during the previous seasons (2017) prior to the survey dates (September 2017). The total acreage for crop production was computed as the sum of acreage covered by crops regardless of what crop was sown. Figure 9 shows that on average, crops were planted on 2.6 acres of land per season. The average acreage in production during the previous season (first season) did not significantly differ across the study districts. However, female-headed households had a significantly lower average acreage than male-headed households.

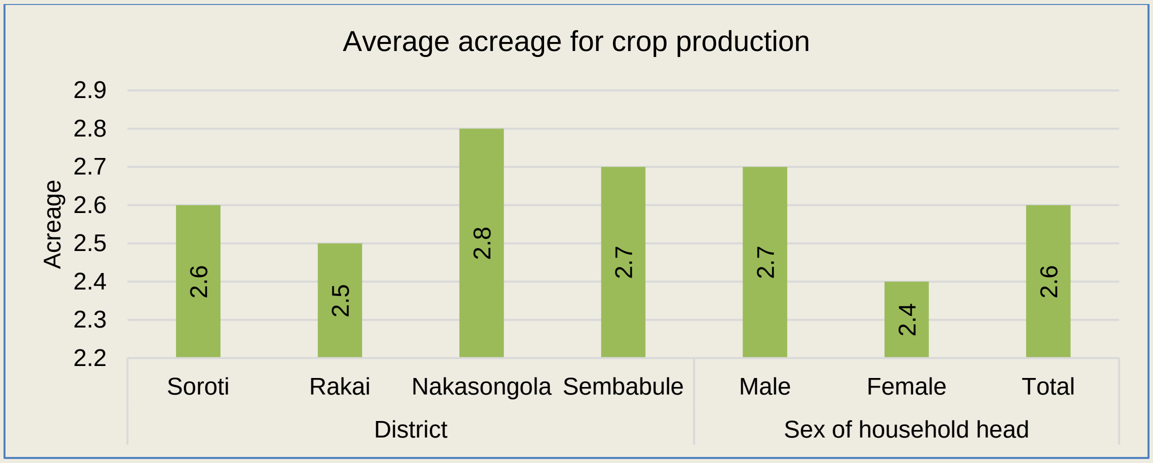

Figure 9: Acreage for crop production by season

The majority (56%) of households had land under crop production ranging between 2 and 10 acres during the season. The proportion of households with plots of land above 2 acres had increased as compared to the status reported during Wave-I. The CHAI-3rd Technical Report (2017) indicated that most of the respondents (41%) in the four districts allocated between 2.6 – 10 hectares of land to agriculture in 2015, and 43% in 2016.

5.3.4 Use of improved crop varieties and cuttings

Figure 10 shows the proportion of households that used improved seeds for the most commonly grown crops. The survey findings generally noted minimal use of improved seeds and cuttings for the crops grown. Maize and cassava were the leading crops for which improved seeds and cuttings were respectively used. Figure 10 shows that only 11%, 8% and 4% of the sampled households used improved seed stock for maize, cuttings for cassava, and bean seeds respectively for planting in the year prior to the survey.

Nakasongola had the highest proportion of households that used improved maize seeds (23%) followed by Sembabule (13%). On the other hand, households that used improved cassava cuttings were highest in Soroti (21%) and Nakasongola (16%). Regardless of the type of crop, Rakai recorded a significantly lower proportion of households using improved crop stock as compared to the other districts.

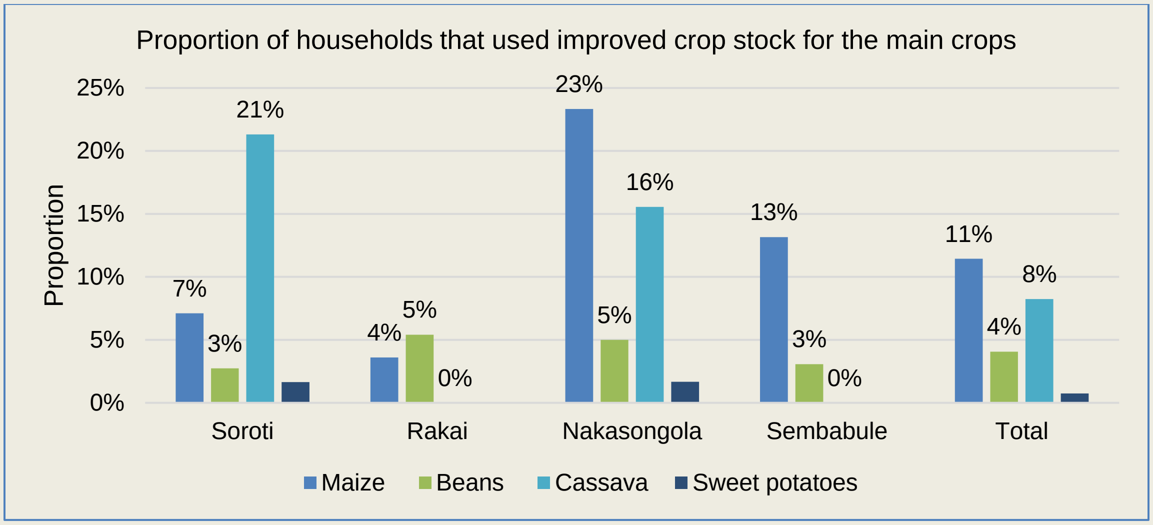

Figure 10: Proportion of households that used improved crop stock for the main crops

About half of the sampled households incurred costs for the acquisition and use of improved seeds (Soroti=27%, Rakai=50%, Nakasongola=59%, Sembabule=61%). Overall, households spent an average of UGX 43,000 ($12) for improved seeds, but with variations across the study districts with the highest expenditures recorded in Soroti and Rakai.

	Soroti	Rakai	Nakasongola	Sembabule	Overall
None	26.8	49.5	59.4	60.5	49.7
<= UGX 50,000	35.0	22.1	25.6	28.9	27.7
<=UGX 100,000	13.7	13.1	6.1	5.7	9.6
<= UGX 150,000	8.7	5.9	1.7	1.8	4.4
<= UGX 200,000	4.4	2.3	1.1	0.9	2.1
>UGX 200,000	11.5	7.2	6.1	2.2	6.5
Total	100.0	100.0	100.0	100.0	100.0
Average expenditure on improved seedlings	UGX 53,444	UGX 53,189	UGX 29,730	UGX 27,048	UGX 42,707

Table 19: Expenditure for improved seeds and cuttings

5.3.5 Crop Loss and Damage

Loss by type of crop

The study found that farmers across study districts incurred crops losses and damages due to prolonged drought, floods, unpredictable rainfall, wind, and hailstorms. In Nakasongola, 34.4% of the respondents incurred loss and damage in maize, 18.5% in groundnuts, 14.8 % in cassava, 14.8% in sweet potatoes, and in 4.2% beans. Other crops that incurred loss and damage include bananas, cotton, millet, and tomatoes. In Sembabule, 34.7% of the households incurred loss and damage in beans, 26% in maize, 7.6% in coffee, 3.4% in cassava, and 2% in groundnuts. Other crops that incurred loss and damage include millet, sweet potatoes, Irish potatoes, and bananas.

In Soroti, 23.7% of respondents reported loss and damage in groundnuts, 23.1% in cassava, 14.1% in millet, 8.5% in sorghum, 6.2% in maize, 5.9% in green gram, 5.1% in sweet potatoes, and 4.8% in peas. Other crops that incurred loss and damage include beans, cowpeas, oranges, tomatoes, soybean, and sesame seeds.

In Rakai, 30.6% of the households incurred loss and damage in beans, 21.8% in maize, 15.9% in bananas, 12.7% in Irish potatoes, 1.4% in cassava, and 1.1% in sweet potatoes. Other crops that incurred loss and damage include coffee, matooke, groundnuts, millet, and sorghum.

Crop Loss and Damage in Acres

Farmers were asked to estimate the number of acres on which they incurred crops loss and damage due to the four most severe hazards. The study showed that Rakai experienced the most crop loss and damage by this measure (5.8 acres), followed by Sembabule district (5.1 acres), Soroti district (3.7 acres), and Nakasongola district (3 acres).

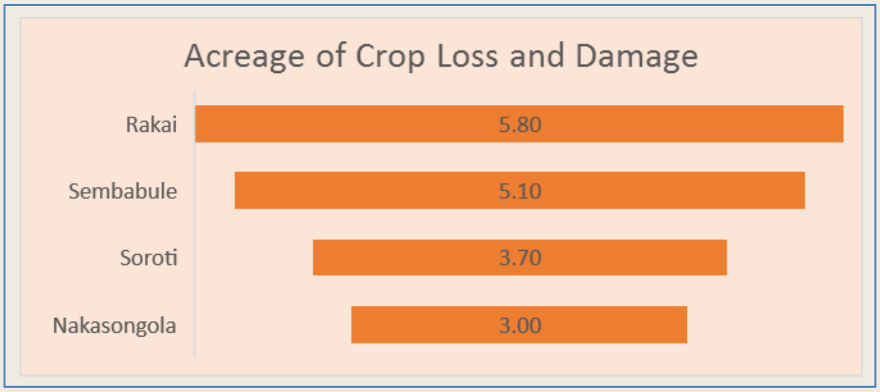

Figure 11: Crop Loss and Damage in Intervention Districts and Control District (Rakai)

Overall, the control district of Rakai sustained higher crop loss and damage in terms of acreage than did the intervention districts.

Estimated Monetary Value of Crop Loss and Damage

Farmers were asked to estimate the monetary value of crop loss and damage incurred due to the most severe hazards (water stress, floods, plant diseases, and hailstorms) experienced over the prior 12 months.

Results from the first wave of the study conducted in September 2016 show that the control district of Rakai sustained the highest crop loss and damage ($520/year/household) followed by Sembabule ($464/year/household), Soroti $303/year/household), and Nakasongola ($209/year/household).

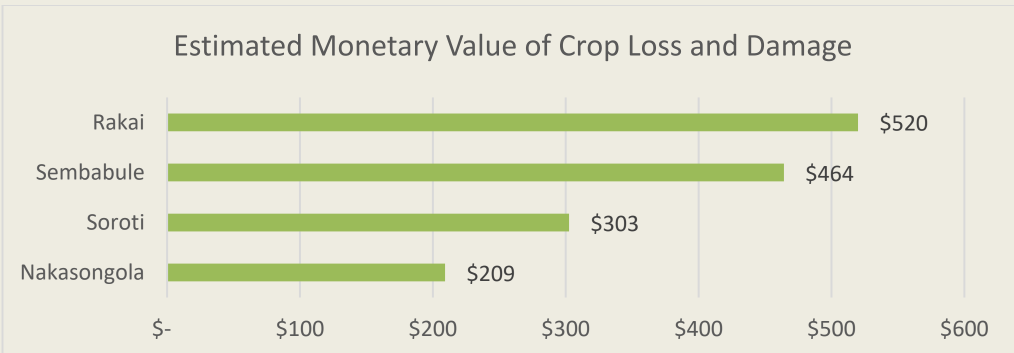

Table 20: Estimate value of crop loss and damage per household per year (1st wave of the study conducted in September 2016)

Households in the control district of Rakai sustained about 11% more crop loss than did households in Sembabule, 42% more than households in Soroti, and 60% more than households in Nakasongola. During the first wave of the study (Sept 2016), *the average monetary value of crop loss for the intervention districts was $325/year/household showing that the control district of Rakai sustained 37% more than the intervention districts in crop loss.*

However, the magnitude of crop loss in the study districts showed a different pattern during the second wave of the study conducted in September 2017. The intervention district of Nakasongola sustained the highest annual crop loss per household (UGX 896,945 or $249) followed by Soroti (UGX 714,636 or $199), the control district of Rakai (Rakai UGX 690,170 or $192), and Sembabule with the lowest loss (UGX 581,736 or $162). During the second wave of the study (Sept 2017), *the average monetary value of crop loss for the intervention districts was $203/year/household while the control district of Rakai sustained $192/year/household showing that the control district of Rakai sustained 6% less than the intervention districts in crop loss.*

Overall, compared to the study conducted in September 2016 (1st wave), crop loss has significantly decreased across the study districts (Sembabule 65%, Rakai 63%, Soroti 34% reduction) except in Nakasongola where, on average, crop loss increased by 19%. The significant reduction is primarily due to better climatic conditions in 2017 compared to

2016. Records from the Meteorology Authority indicate that the drought situation in 2017 was significantly lower than 2016.

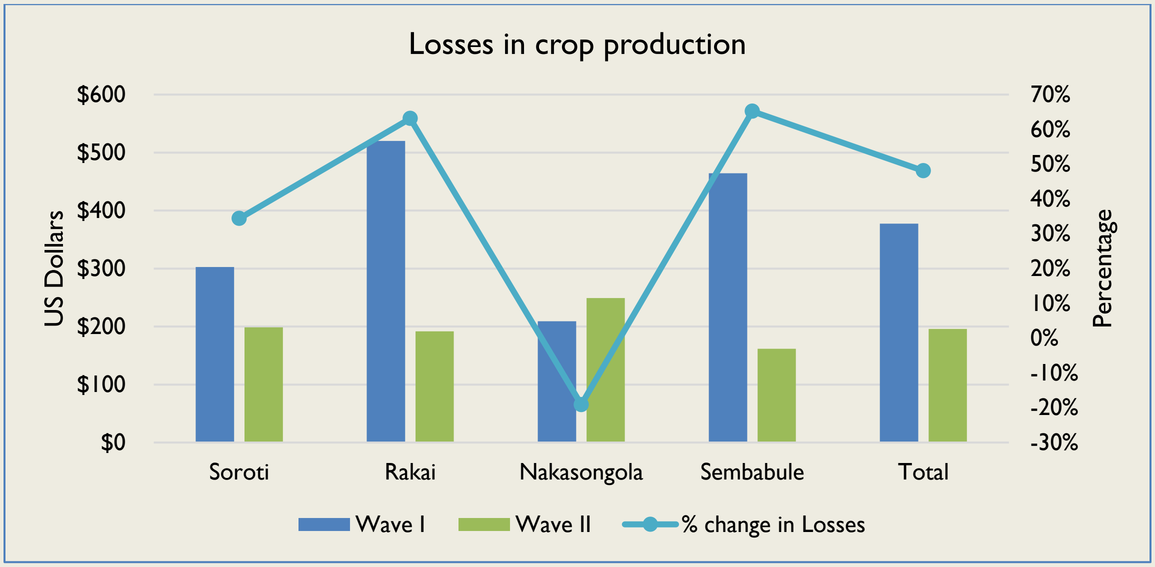

Figure 12: Losses in crop production during wave-1 (Sept 2016) and wave 2 (Sept 2017); and proportion of decrease or increase in crop loss during wave-2 compared to wave-1 (negative % shows increase in crop loss).

As will be shown in a subsequent section, the intervention districts were severely affected by fall armyworm compared to the control district of Rakai during the second wave of the study resulting in more cop losses. The gains made by enhanced use of climate and agriculture information in the intervention districts were lost by the devastating impacts of fall armyworm that affected crop production especially maize.

5.3.6 Constraints to crop production

Table 20 shows the proportion of households that faced the most common constraints to crop production. Overall, about 83% of the households were constrained by drought, 56% were constrained by pests and diseases. The proportion of households that reported being constrained by drought, pests, and diseases differed significantly across the study districts. Rakai had the lowest proportion of households reporting pests and diseases as constraints to crop production (40%) while Sembabule had the highest (68%). On the other hand, Soroti had the highest proportion of households that reported having drought among the factors that constrained crop production, while Sembabule recorded the lowest.

Proportion of households that reported each of the constraints to crop production

	Soroti	Rakai	Nakasongola	Sembabule	Overall
Drought	94.0	89.2	85.6	68.4	83.6

Pests/diseases/Rodents	55.7	39.6	61.1	67.5	55.8
Infertile land	6.6	27.9	1.1	13.2	13.0
Limited market	3.3	21.6	2.2	6.6	9.0
Domestic animals	12.6	9.9	14.4	0.4	8.9
Limited labor	16.4	11.7	0.6	2.6	7.7
Theft	14.8	6.3	1.7	6.1	7.1
Other wild animals	2.7	5.4	20.6	1.3	7.0
Too much rain (floods)	4.4	12.6	1.1	7.9	6.9
Lack of household storage space	0.0	4.5	0.0	0.9	1.5

Table 21: Constraints to crop production

It is very important to note that farmers from the control district of Rakai had the lowest challenges related to pests, plant diseases, and rodents. The infestation of fall armyworm was particularly severe in the intervention districts compared to Rakai.

The Community Development Officer in Sembabule district described the occurrence of drought, destructive winds, and fall armyworm infestations in the parishes of Nyakasenyi, Kasambya, and Rwebitakuli. He noted that "Farmers' crops were destroyed especially the maize, banana plantations, beans and they are the most common crops grown here. The damage was so much to the extent of getting help from the Office of the Prime Minister. We were mainly affected on the crop production and houses were destroyed".

An agricultural production officer in Rakai noted that while the crop loss due to drought was very significant, "the impact of crop loss due to fall armyworm was less pronounced compared to neighboring districts such as Sembabule".

5.4 Agricultural Support Practices

5.4.1 Access to Credit Services

Only about one in five households had access to credit services in 2016 and 2017. Soroti (35%) had the highest proportion of households with access to credit followed by Sembabule (24%), Rakai (14%), and Nakasongola (13%) (Figure 13). Male-headed households had slightly better access to credit (24%) than female-headed household (20%), however, the difference was not statistically significant.

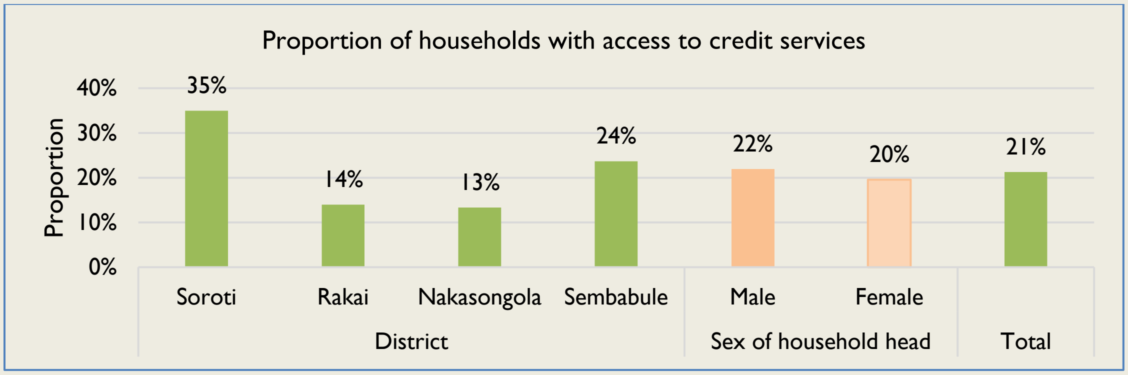

Figure 13: Proportion of household with access to credit services

The leading sources of credit included informal savings and credit groups (43%), Savings and Cooperative Organizations (27%), and formal financial institutions (20%). On average, households received credit of \$139, but the figure was relatively higher in Rakai (\$226) than in the other districts. Soroti had the lowest average credit (\$95) (Table 22).

The findings demonstrate a relationship between the average amounts borrowed and the sources of credit. For example, Soroti recorded the lowest value of credit partly because the majority of the households borrowed from informal savings and credit groups. On the other hand, Rakai had the highest average amount borrowed with majority of credit accessed from formal financial institutions or Savings and Credit Cooperative Societies (SACCO) Households that had credit from financial institutions (banks, micro-finances) and SACCOs tended to have access to relatively higher amounts of credit than those borrowing from informal saving and credit groups.

The leading purposes for the credit included crop production such as for buying agricultural inputs (36%), paying for school fees and uniforms (27%), animal/livestock production (8%), starting businesses (8%), purchasing food (6%), and covering medical expenses(6%).

Source of credit	Soroti %	Rakai %	Nakasongola %	Sembabule %	Overall (%)
Informal savings and credit group	70.6	12.9	37.5	27.8	42.9
SACCOs	10.3	35.5	29.2	42.6	27.1
Bank or micro-finance institution	14.7	41.9	20.8	13.0	19.8
Relatives and friends	1.5	0.0	12.5	16.7	7.3
Money lender	0.0	9.7	0.0	0.0	1.7
NGO/Church	2.9	0.0	0.0	0.0	1.1
Amount borrowed	%	%	%	%	%
<=100,000	35.9	16.1	19.0	22.2	25.9
<=500,000	46.9	29.0	42.9	44.4	42.4

<=1m	10.9	16.1	9.5	13.0	12.4
>1m	6.3	38.7	28.6	20.4	19.4
Total	100.0	100.0	100.0	100.0	100.0
Average amount borrowed (UGX)	342,460	815,385	686,389	468,298	500,909
Purpose of Borrowing credit					
Crop production	24.2	73.3	14.3	37.0	35.7
School fees for children	31.8	13.3	33.3	25.9	26.9
Animal production	4.5	0.0	23.8	9.3	7.6
Start business	13.6	3.3	4.8	3.7	7.6
Purchase of food	12.1	3.3	4.8	1.9	6.4
Cover medical costs	9.1	0.0	4.8	7.4	6.4
Purchase of assets/land	0.0	3.3	9.5	11.1	5.3
Others	4.5	3.3	4.8	3.7	4.1
Total	100.0	100.0	100.0	100.0	100.0

Table 22: Sources and purposes of credit

5.4.2 Access to Extension Services

On average, only 9% of the sampled households were visited by an extension worker. Soroti (14%) had the highest proportion of households that reported receiving extension services followed by Rakai (8%), Sembabule (7%), and Nakasongola recording the lowest (6%).

Utilization of extension services greatly varied by the sex of the head of household. Results presented in Figure 14 show that only 5% of the female-headed households as compared to 10% of their male counterparts received extension services.

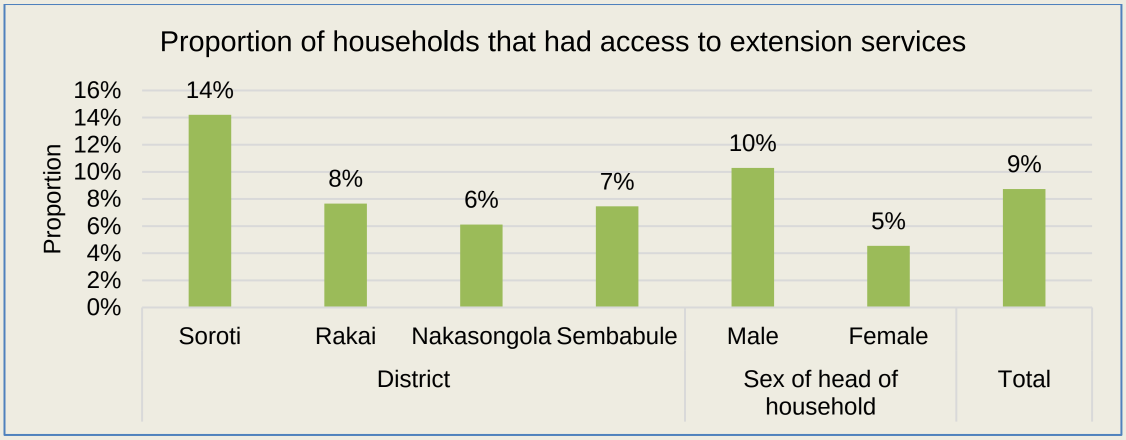

Figure 14: Proportion of households with access to extension services

Key informant interviews with extension workers showed that the extension workers have vast geographical areas to cover making it hard to reach and serve individual farmers. Subsequently, they relied on the farmers reached to help pass on the acquired information to others.

An extension worker in Rwemiyaga, Sembabule District noted that "*you find you have a total of 60 villages, so you can't say you are going to move into each and every village. So, what you do is to mobilize some farmers say at the parish level, train them, demonstrate what is supposed to be done then you let them go. Because you find that a farmer here has a neighboring farmer, so you train him to go and train his fellow farmer on what he is supposed to do so that the message can spread within the quickest time possible*".

5.4.3 Membership to Business Associations or Groups

The respondents were asked if they or a household member belonged to a business association or group that aims to help its members improve their farming and market activities. Results presented in Figure 15 show that, overall, only one in six households belonged to a business association.

Sembabule and Soroti had the highest proportion of households with a member belonging to a business group or association, each recording about 2 out of 9 households belonging to a group. Only 1of 9 households in Rakai and Nakasongola had a member belonging to an association or group.

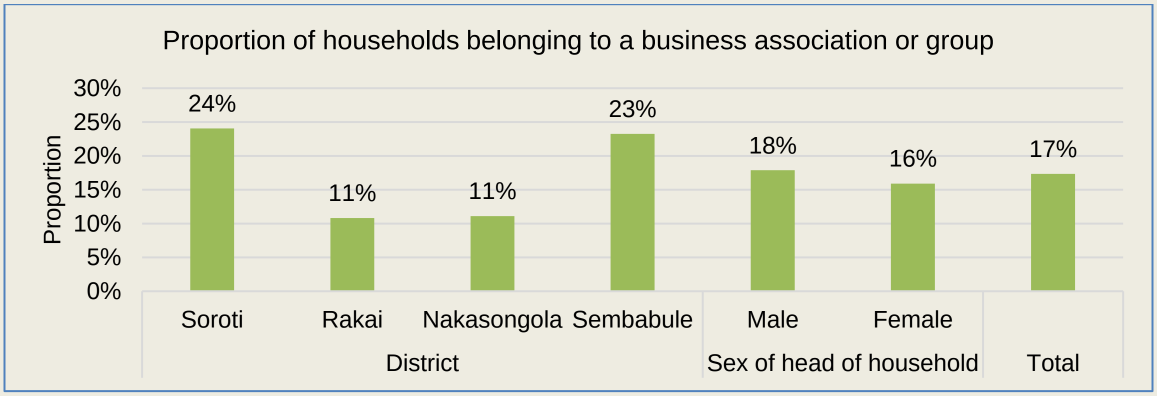

Figure 15: Proportion households with membership in an association or group

The benefits from the business associations/groups to which the members belonged included access to credit and savings (40%), training in better farming practices (17%), networking (17%), and marketing / buying agricultural inputs (12%). Other benefits include provision of raw materials, e.g. seeds and animals. (Table 23)

Benefits	Soroti	Rakai	Nakasongola	Sembabule	Overall
Savings and credit	43.6	58.8	16.7	44.4	40.3
Train in better farming methods	17.9	0.0	26.7	17.5	17.4
Help us network	12.8	17.6	23.3	15.9	16.8
Look for markets	5.1	11.8	20.0	3.2	8.1
Buy our products	5.1	0.0	6.7	3.2	4.0
Give us raw materials at low costs	5.1	5.9	3.3	1.6	3.4
Support in hardships	0.0	5.9	0.0	4.8	2.7
Give animals	2.6	0.0	0.0	4.8	2.7
Give seeds	5.1	0.0	0.0	3.2	2.7
Offer adult training/education	2.6	0.0	3.3	1.6	2.0
Total	100.0	100.0	100.0	100.0	100.0

Table 23: Benefits attained from the associations or groups

5.4.4 Agricultural Products Marketing Strategies

Only about 13% of the respondents reported that they inform their decision to sell agricultural products based on pre-acquired information rather than simply taking their product to the market. Most of the households used the conventional word of mouth (54%) followed by simply taking the product to the market (17%), reflected through telling a colleague, phone calls, and physical delivery of products to the selling points/markets. The use of marketing avenues such as radio and TV adverts, use of social media, business cards, newspapers, flyers, and brochures among others was minimal (Table 24)

	Soroti	Rakai	Nakasongola	Sembabule	Overall
Word of mouth	74.3	0.0	40.6	0.0	54.8
Taking it to market	14.9	100.0	6.3	41.2	16.9
Phone calling customers	6.8	0.0	28.1	11.8	12.9
Others	4.1	0.0	25.1	47%	16.2
% marketing	35%	0%	15%	7%	13%

Table 24: Marketing strategies used by households

5.5 Access to and Use of Climate and Agricultural Information

5.5.1 Access to Climate and Agricultural Information

As illustrated in Figure 25, the study showed a significant variation in the proportion of respondents with access to climate and agricultural information by district ($p<0.05$). Soroti had the highest proportion of respondents with access to climate and agricultural information (77%) followed by Sembabule (56%), Nakasongola (45%); in the control district of Rakai only 9% of respondents had access to such information. Overall, only about 4 in 9 households received information related to weather.

A higher proportion of male-headed households (48%) received climate and agricultural information than did female-headed households (38%).

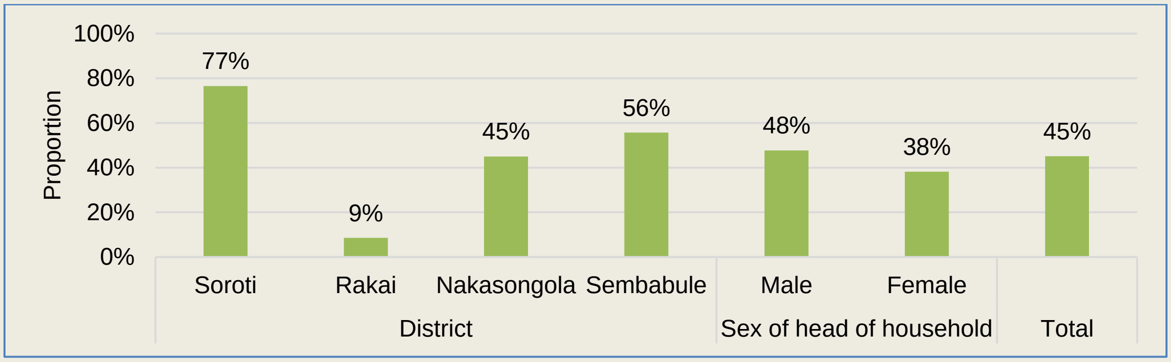

Table 25: Proportion of households receiving climate and agricultural information

Households in Soroti district were 34 times more likely to have received weather- related information than their counterparts in Rakai (OR=34.8, $p<0.05$). On the other hand, households in Nakasongola were 8 times more likely to have received weather related information as compared to those in Rakai (OR=8.7. $p<0.05$). Comparisons between Sembabule and Rakai show that the households in Sembabule were 13 times more likely to have received weather information as compared to the control district of Rakai. The male-headed households were 1.5 times more likely to have received weather related information than the female-headed households (OR=1.5, $p<0.05$).

The types of climate and agricultural information received by households included information on the onset and cessation of rainfall and associated agricultural advisories (35%), drought and associated agricultural advisories (31%), heavy rains (25%), storms (5%) and wind (3%).

Type of information	Soroti	Rakai	Nakasongola	Sembabule	Overall
Onset/cessation of rainfall and agricultural advisories	36.6	16.7	55.2	25.2	34.8
Drought info and associated agricultural advisories	29.8	33.3	34.3	29.2	30.5
Heavy rains/floods	23.4	50.0	9.5	31.4	25.0
Storms	4.2	0.0	0.0	9.3	5.2
Wind	3.8	0.0	0.0	4.9	3.4
Others	2.3	0.0	1.0	0.0	1.1
Total	100.0	100.0	100.0	100.0	100.0

Table 26: Types of climate and agricultural information received by households

5.5.2 Source of Climate and Agricultural Information

Farmers participating in the study were asked to indicate the sources of climate and agricultural-related information that they receive. Overall, the main source of climate and agricultural information for the participating households was **FM radios** (58%), followed by SMS (20%). Access to climate and agricultural information through FM radio was highest in the control district of Rakai (82%), followed by Soroti (64%), Nakasongola (54%), and Sembabule (50%). Access to similar information through **SMS** was highest in Sembabule (34%), followed by Nakasongola (25%) and Soroti (6%); no *respondents from the control district of Rakai reported access to information through SMS*.

Information source / channel	Soroti	Rakai	Nakasongola	Sembabule	Overall
FM Radio	63.6	81.8	54.1	49.7	57.5
SMS	5.8	0.0	25.2	34.4	19.7
Word of mouth	25.4	22.7	18.0	13.9	19.7
Community loudspeakers	2.9	4.5	3.6	2.6	3.1
Newspapers	2.3	0.0	0.0	0.0	0.9
Total	100.0	100.0	100.0	100.0	100.0

Table 27: Sources (channels) of climate and agricultural information

The proportion of households that reported **word of mouth** as a source of information was highest in Soroti (25%), followed by Rakai (23%), Nakasongola (18%) and Sembabule (14%). Only about 3% of the respondents reported receiving climate and agricultural information through **community loudspeakers** (Rakai, 5%; Nakasongola, 4%; Soroti, 3%; and Sembabule 3%). **Newspapers** as a source of climate and agricultural information was reported only in Soroti (2%). Generally, regardless of the channel of information, a significantly high proportion of households in the intervention districts received climate and agricultural information compared to the control district of Rakai.

5.5.3 Willingness and Ability to Pay for Climate and Agricultural Information

Willingness and ability to pay is one of the important foundations of the economic theory of value. The CHAI project disseminates climate and agricultural information deemed to be useful to small-holder farmers for minimizing the risks emanating from unpredictable weather and changing climate. If the information services provided by the project is worth having by the farmers, then it is assumed that the farmers will find the information worth paying for. Farmers' willingness to pay for CHAI information is the most fundamental indication of the value of the information services. To understand the value of climate services provided by CHAI, the project conducted a survey of farmers' ability and willingness to pay for climate and agricultural information services. The survey was administered as part of the first and second waves of the study.

Demand for Climate and Agricultural Information

Respondents were asked to indicate the climate and agriculture-related variables for which they need information for planning crop and livestock production.

Information on drought has the most demand across the intervention and control districts (86.3%) followed by the start date of rainfall (51.2%), rainfall variability patterns (44.9%), duration of rainy season (31.4%), extreme rains (29.3%), length of rainy season (15.5%), number of rainy days in a season (14.6%), advisories on storms (8.2%), duration of dry-spells (7.1%), floods (5.3%) and wind (5.2%).

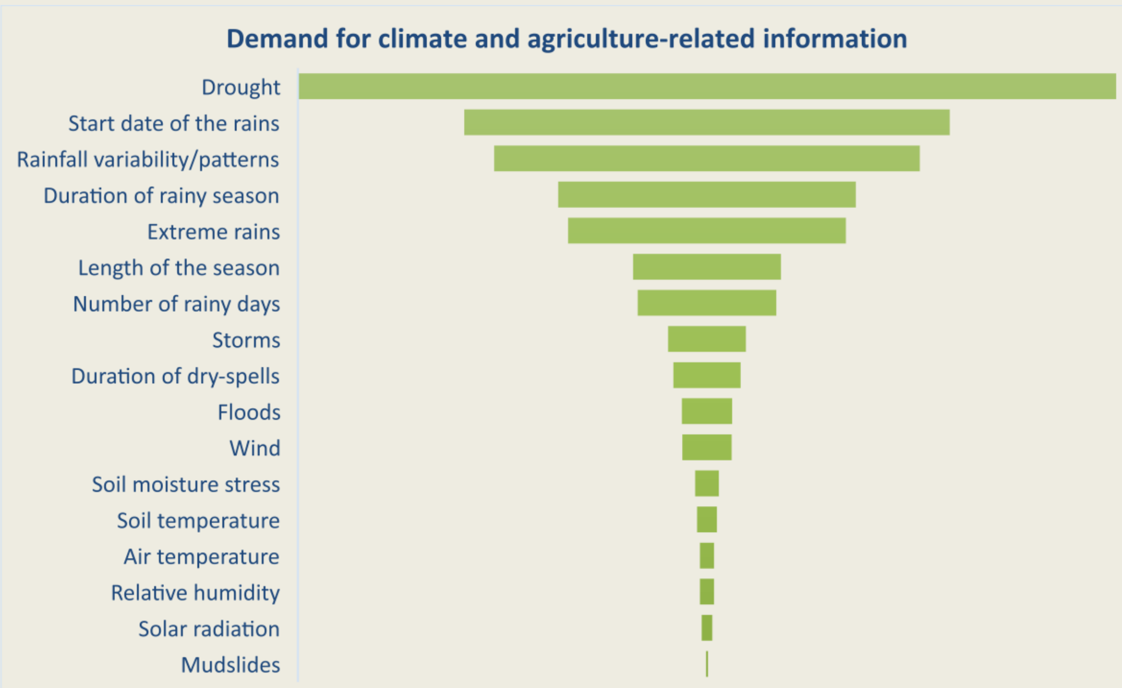

Figure 16: Demand for climate and agricultural information by farmers in the control and intervention districts

It is important to note that the overwhelming majority of households' climate and agriculture-related information needs are water related. Apart from the need for wind-related information that 5.2% of the households indicated as useful, the rest are related to water.

There are variations in the demand for climate and agriculture-related information in the four districts. The following table provides data on information demand by district and the average for the control and intervention districts.

Climate related variable	*All Districts*	*Nakasongola*	*Rakai*	*Sembabule*	*Soroti*

Drought	86.3%	78.9%	83.5%	85.9%	97.8%
Start date of the rains	51.2%	54.0%	59.7%	24.7%	73.7%
Rainfall variability/patterns	44.9%	28.1%	37.9%	40.0%	75.9%
Duration of rainy season	31.4%	14.6%	39.1%	15.4%	63.3%
Extreme rains	29.3%	8.6%	22.1%	32.5%	61.2%
Length of the season	15.6%	0.7%	35.7%	5.3%	30.7%
Number of rainy days	14.6%	1.3%	15.9%	3.4%	48.6%
Storms	8.2%	0.7%	10.7%	9.5%	15.2%
Duration of dry-spells	7.1%	-	1.2%	3.4%	26.2%
Floods	5.3%	-	4.8%	2.7%	17.3%
Wind	5.2%	1.3%	7.1%	4.7%	10.2%
Soil moisture stress	2.5%	4.6%	1.2%	-	4.1%
Soil temperature	2.1%	1.3%	7.0%	-	2.1%
Air temperature	1.5%	-	3.6%	-	4.2%
Relative humidity	1.5%	-	-	-	7.1%
Solar radiation	1.1%	-	1.2%	-	4.1%
Mudslides	0.2%	-	1.2%	-	-

Table 28: Demand for climate and agricultural information by district

Types of Information for which Farmers are Willing to Pay

To understand the types of information that they are willing to pay for, farmers were asked to select the information that they ascribe value to and for which they are willing to pay. Farmers were willing to pay for drought-related information (83.3%), followed by the start date of rainfall for a season (59.1%), rainfall variability (55.3%), duration of rainy seasons (42.9%), extreme rainfall events (34.6%), length of rainy seasons (28.6%), and number of rainy days (25%).

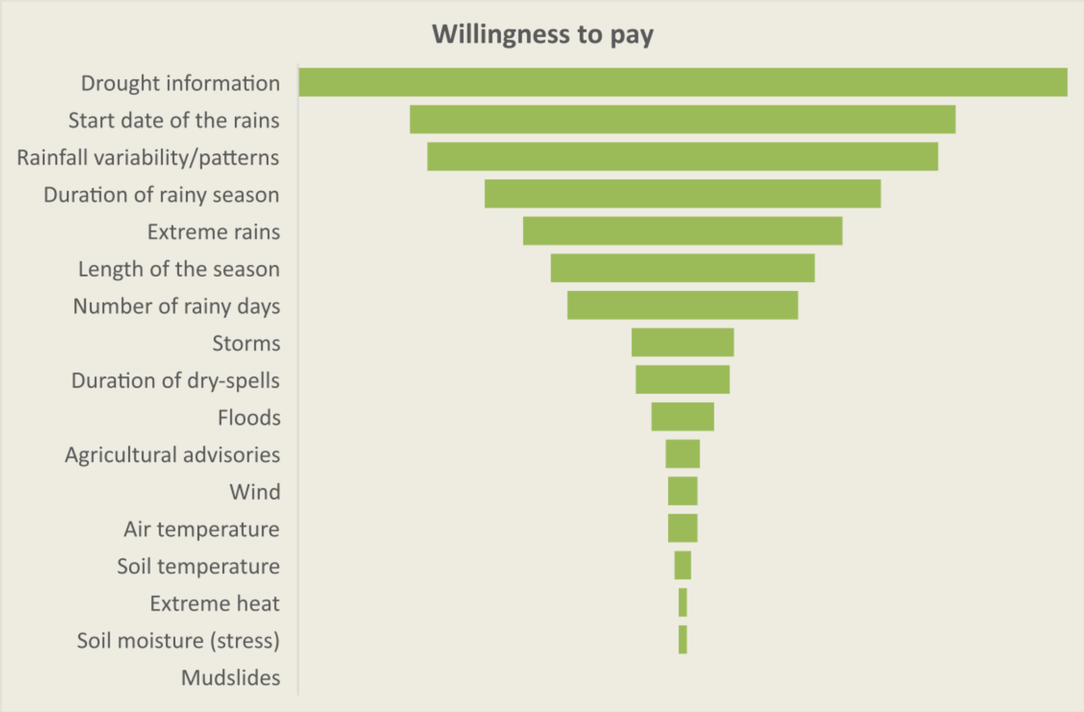

Figure 17: Farmers willingness to pay for climate and agriculture-related information

Proportion of Farmers Willing to Pay for Climate and Agricultural Information

Respondents were asked about their willingness and ability to pay for climate and agricultural information. Only about **35% of the respondents indicated to be willing and able to pay for such information.** Willingness to pay for climate and agricultural information significantly differed by district. Soroti had the highest (49%) proportion of respondents willing to pay while Nakasongola had the lowest (11%). A relatively higher proportion of respondents in male-headed households than in female-headed households were willing to pay for such information (Figure 18).

The limited willingness to pay is partly attributed to the perception of some respondents that they were able to predict future weather conditions by themselves using traditional approaches. Over 40% of the respondents indicated they were able to predict weather changes by themselves; the highest proportion was in Nakasongola (52%).

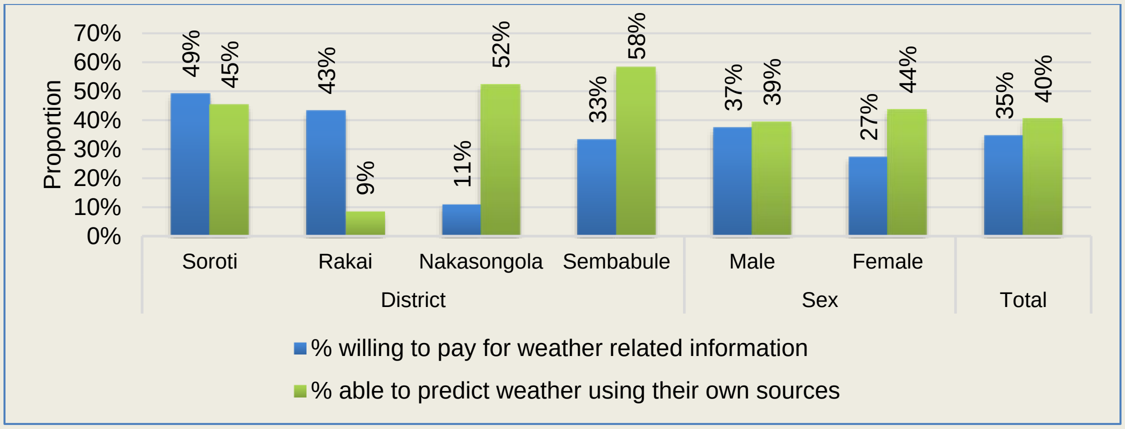

Figure 18: Proportion of farmers willing to pay for climate and agricultural information

Amount Farmers are Willing to Pay for Climate and Agricultural Information

Respondents' willingness and ability to pay for climate and agricultural information significantly varies between the project's first (Sept 2016) and second (Sept 2017) wave surveys.

The average willingness and ability to pay during the first survey was $9.25/year/household. The first survey showed that farmers in the control district of Rakai were willing and able to pay the highest amount (UGX 6,525 or $12.62/year) followed by Soroti (UGX 5,050 or $9.55/year), Sembabule (UGX 2,483 or $4.49/year), and Nakasongola (UGX 2,079 or $4.48/year).

District	*Seasonal Forecasts*	*Daily Weather*	*10-day forecast*	*Agricultural Advisories*	*Water Harvesting Info*	*Total UGX*	*Total USD*
All districts	3,016	6,350	5,004	13,347	5,582	33,299	$9.25
Nakasongola	1,815	2,938	1,352	6,896	3,117	16,118	$4.48
Rakai	3,029	7,937	6,469	19,899	8,083	45,417	$12.62
Sembabule	1,741	4,900	1,472	4,777	3,280	16,170	$4.49
Soroti	4,664	0	7,718	16,033	5,969	34,384	$9.55

Table 29: Amount farmers are willing to pay for climate services by district

On average, farmers indicated willingness to pay $12.62/year in Rakai for all-inclusive climate services, $9.55 in Soroti, $4.49 in Sembabule, and $4.48 in Nakasongola.

During the second survey conducted in September 2017, the amount sampled households were willing to pay fell significantly from $9.25/household/year to an average of $2.03/household/year. By district, the average respondent was willing to pay $3.06/year in Soroti, $1.47/year in Sembabule, and $1.39/year in Rakai and Nakasongola.

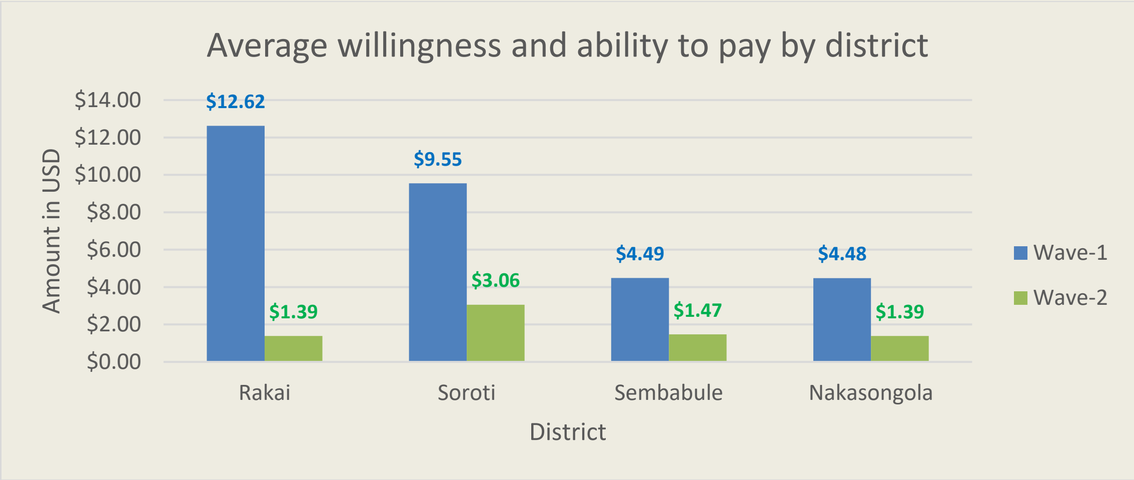

Figure 19: Average willingness and ability to pay by district during the first wave (Sept 2016) and second wave (Sept 2017) of the surveys

The average willingness and ability to pay for the intervention districts and the control district are provided in the following table.

Group	Willingness / ability to pay		
	Wave-1 (Sept 2016)	*Wave-2 (Sept 2017)*	*2016 and 2017 combined average*
Intervention districts (combined)	$6.17	$1.97	$4.07
Control district	$12.62	$1.39	$7.01

Table 30: The intervention districts' average willingness and ability to pay for 2016 and 2017 combined is $4.07/year/household.

As shown in **Table 30**, the intervention districts' average willingness and ability to pay for 2016 and 2017 combined is $4.07/year/household while respondents from the control district indicated willingness to pay an average of $7.01/year/household.

The farmers who indicated unwillingness to pay for climate services were asked to provide the reasons why. The primary reason given was that they believed such information to be a public good that should be provided by the government for free (Soroti 80%, Rakai 75%, Sembabule 68.2%, Nakasongola 45.8%). The next most frequently given reason for unwillingness to pay was that it is expensive (Rakai 65.6%, Sembabule 48.8%, Nakasongola 48.6%, and Soroti 42.9%).

Reason	*All Districts*	*Nakasongola*	*Rakai*	*Sembabule*	*Soroti*
It should be provided free	62.1	45.8	75.7	68.2	80
It is expensive	48.6	45.3	65.6	48.8	42.9
It is not useful	8.8	16.8	9.1	1.3	0
I am not interested	3	5.7	0	1.3	0

Table 31: Reasons for Unwillingness to Pay for Climate Services

5.6 Gender Analysis

The impacts of climate change tend to vary by social status, gender, poverty, power and access to and control over resources. The impacts of climate change acutely affect poor and marginalized segments of society such as women, children, and people who are elderly or disabled. Gender-based inequalities caused by unjust laws and practices, society-defined gender roles and sociocultural constraints make women disproportionately vulnerable to the impacts of climate change. With the negative impacts of climate change likely to increase in Uganda (MAAIF 2008), enhancing the adaptive capacity of communities including women is a priority to minimize risks.

To ensure that the needs and priorities of women are included in the development of climate and agricultural information, the study design prescribed that at least 25% of the household heads interviewed per village to be women.

This section details the outcomes of the study in relation to differences in levels of education and access to resources such as land and affordable loans between the genders, and how these disparities affect the relative risks of climatic hazards for women and men.

5.6.1 Occupation and Levels of Education

The study aimed to include a minimum of 25% of survey respondents to be female household heads. Of the 813 households surveyed during the second time point of the study, 593 (73%) were male headed and 220 (27%) female headed. The distribution of heads of households by sex did not significantly differ across the study districts ($p>0.05$).

The household head is mainly responsible for the economic well-being of the household. 77% of heads of household were married while 15% were widowed, 6% had divorced/separated and 3% were never married. The distribution of the heads of household by marital status did not significantly differ across the study districts. However, there were substantial variations in the marital status by the sex of heads of households ($p<0.05$). Whereas over 90% of the male heads of households were married, 71% of female heads of households were either widowed, separated or never married. The unmarried status of these female heads of household is likely to negatively impact their ability to provide livelihood to households as compared to married households. Focus group discussions with women-only groups revealed that they rely on hired labor to assist them in farming activities.

Education Levels

Overall, the study showed that, regardless of gender, 60% of heads of household either never attended school or dropped out before completing the primary cycle; 40% completed primary education. Female household heads were less likely to have attained higher education levels as compared to their male counterparts: 46% of the male heads of households as compared to 22% of their female counterparts had completed primary or higher education level.

The relatively lower education levels of women household heads contributed to their increased vulnerability to the impacts of climate change. A female focus group discussant in Sembabule noted that “illiterate women face double jeopardy. As women, we have less land, and as illiterate women, we cannot read and apply useful information into action which leads to less crop production.” Households with no formal education relied on information received through the radio.; their use of mobile phones to receive climate and agricultural information was very limited. Female-headed households with a literate child or other member of the household used mobile phones to receive climate/agricultural information for the household. About half of the female-headed households had a literate household member able to receive climate/agricultural information for use by the household. To cater to the needs of households with low literacy level, climate/agricultural information was shared with them as voice messages.

Occupation

Globally, women play a central role in providing livelihood to their households and contributing to the economic development of their country; women provide about half of the agricultural labor force in the least developing countries (FAO 2012). In Uganda, women constitute about 44% of the labor force in the formal sector and 48% in the informal. (UBOS 2017).

The study showed that 90% of the heads of households across all study communities were engaged in farming. Higher proportions of female heads of households (94%) were involved in farming as compared to their male counterparts (86%). The occupation of household heads did not significantly differ between women and men; however women tend to be more dependent on rainfed farming activities than men, increasing their vulnerability to the impacts of unpredictable weather conditions.

5.6.2 Access to Resources

Adaptive capacity to address climate-related risks is affected by access to resources such as land, technology, information, finance and institutional resources (Eakin and Bojorquez-Tapia 2009). The study assessed the differences in access to resources between men and women.

Access to Land and Usage

Women in Uganda have limited opportunities to own land due to customs that decrease the likelihood of their inheriting it and their reduced economic capacity to acquire it themselves. Given the central role land plays in the vitality of the sectors that depend on it for productivity such as agriculture, human settlements, water, and forestry, lack of land ownership constrains the ability of women to provide for their households as the primary caregivers. The study showed that regardless of the study district, female-headed households had access to a relatively lower average number of land parcels and land acreage as compared to their male counterparts. On average, male-headed households had access to 1.7 parcels of land with a total average acreage of 3.1 acres as compared to 1.5 parcels accessed by the female-headed households with a total average acreage of 2.6 showing that male-headed households are likely to own about 0.5 acres more land than female headed households.

The relatively smaller landholdings of female-headed households limited women's ability to diversify agricultural production and increased their vulnerability to climate-related hazards. In key informant interviews, female participants indicated that they usually use their land for crop production because of their relatively smaller landholding compared to men. The household survey confirmed this assessment showing that there was a relatively higher proportion of the parcels used for livestock keeping in the male-headed households as compared to the female-headed households and a relatively higher proportion of the parcels used by the female heads of household as compared to their male counterparts were utilized for crop production (see table below).

	Sex of the head of household	Crop production (%)	Livestock keeping (%)	Homestead (%)	Woodlot/ forestry (%)	Not used (%)	Others (%)
Soroti	Male	77.3	6.2	15.3	0.0	1.2	0
	Female	76.9	3.3	16.5	0.0	3.3	0
	Total	77.2	5.4	15.7	0.0	1.7	0
Nakasongola	Male	77.0	14.2	0.0	1.4	1.4	6.1
	Female	81.8	9.1	0.0	0.0	0.0	9.1
	Total	78.3	12.8	0.0	1.0	1.0	6.9
Sembabule	Male	91.9	6.3	0.4	0.0	0.7	0.7
	Female	94	6.0	0.0	0.0	0.0	0.0
	Total	92.4	6.2	0.3	0.0	0.6	0.6
Rakai	Male	90.4	2.4	5.2	1.0	1.0	0.0
	Female	90.0	1.3	5.0	1.3	1.3	1.3
	Total	90.3	2.2	5.1	1.1	1.1	0.3
Overall	Male	84.6	6.3	6.5	0.5	1.0	1.0
	Female	85	4.4	7.1	0.3	1.5	1.8
	Total	84.7	5.8	6.6	0.4	1.2	1.2

Table 32: Main land use on the parcels owned by the households by district and sex of head of household

Access to Climate and Agricultural Information

By district, results show a significantly higher proportion of households in the CHAI districts having received weather information than those in the control district of Rakai. The households in Soroti district were 34 times more likely to have received weather-related information than their counterparts in Rakai (OR=34.8, $p<0.05$); households in Nakasongola were 8 times more likely to have received weather related information as compared to those in Rakai (OR=8.7. $p<0.05$); and households in Sembabule were 13 times more likely to have received weather information as compared to the control district of Rakai (OR=34. $p<0.5$).

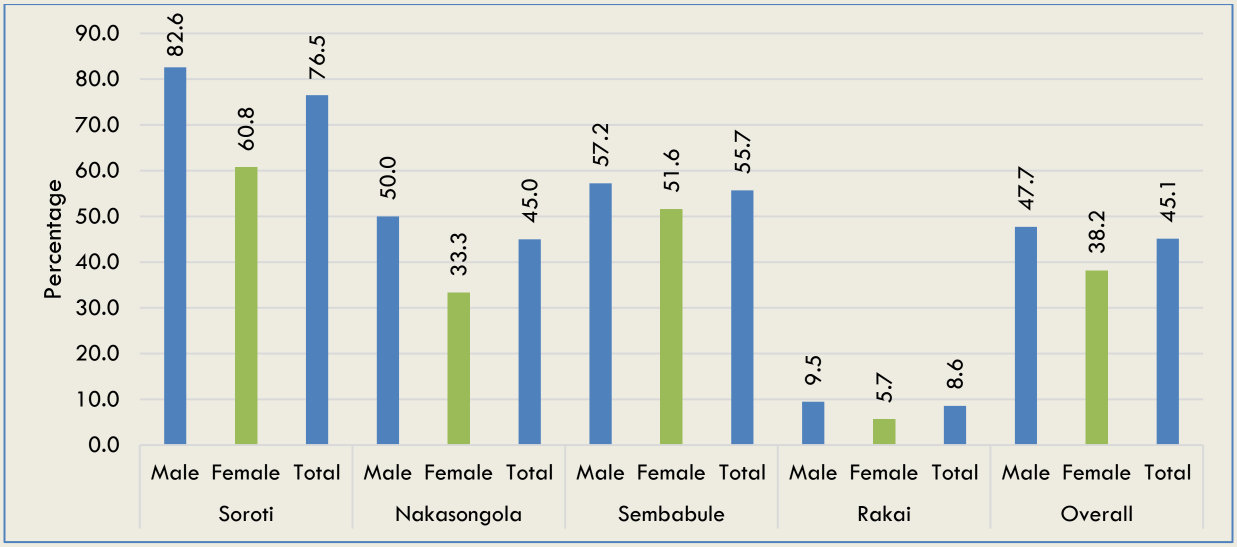

Figure 20: Proportion of households receiving climate and agricultural information by district and sex of head of household

The types of climate and agricultural information received by households included information on the onset and cessation of rainfall and associated agricultural advisories (35%), drought and associated agricultural advisories (31%), heavy rains (25%), storms (5%) and wind (3%). Results do not show significant variations in the type of information between the male and female households.

The study showed that, on average, about 48% of female households had access to climate and agricultural information in the study districts while only 5.7% of female households in the control district of Rakai had access to similar information, showing a significant difference ($p<0.05$). This finding demonstrates that the project has significantly increased women's access to information and thereby contributed to the increased ability of women to adapt to the impacts of climate change.

Access to Credit Services

Only about one in five households had access to credit services in 2016 and 2017. Soroti (35%) had the highest proportion of households with access to credit followed by Sembabule (24%), Rakai (14%), and Nakasongola (13%). A higher proportion of the male-headed households had access to credit (24%) than female-headed household (20%), though the difference was not statistically significant.

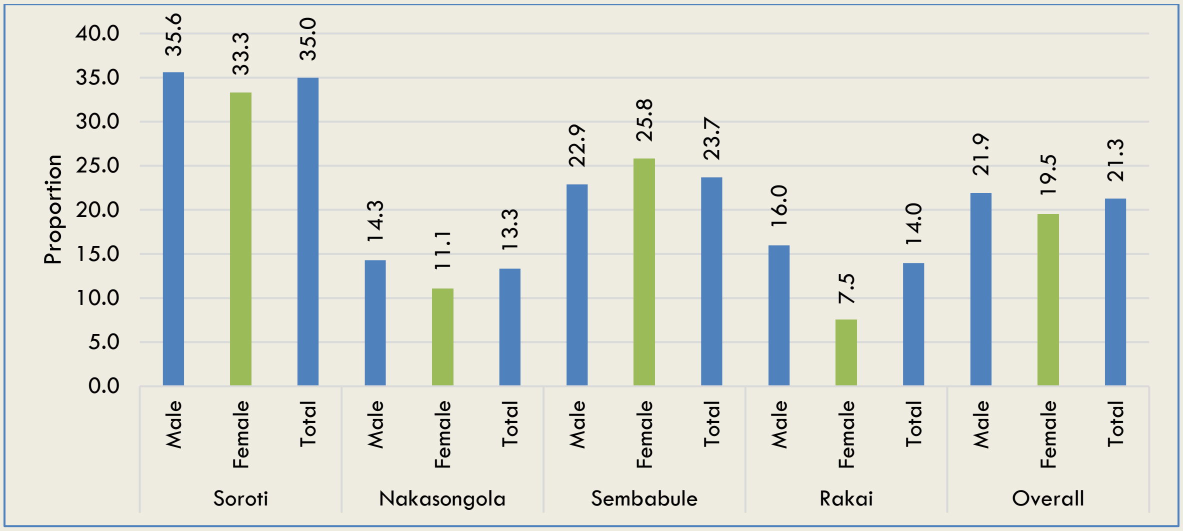

Figure 21: Proportion that have access to credit services by sex of head of household and study district

A relatively lower proportion of the female-headed households had accessed credit from banks or micro-finance institutions as compared to the male heads of household. Informal saving schemes were the leading source of credit for the female-headed household. Overall, the leading sources of credit included informal savings and credit groups (43%), Savings and Cooperative Organizations (27%) and formal financial institutions (20%).

Regardless of the sex of the head of household, the leading purposes for credit included crop production such as buying agricultural inputs, paying for school fees and uniforms, animal/livestock production, starting businesses, purchasing food and covering medical expenses.

Access to credit services by female households in intervention districts was highest in Soroti (33.3% having access), followed by Sembabule (25.8%) and Nakasongola (11.1%). Female households in the control district of Rakai had the lowest access to credit services (7.5%). The higher percentage of access to credit services in the intervention districts is attributed to the project's efforts of linking farmers to credit providers ("action resources"). Female focus group discussants in the intervention districts noted that the project-supplied information about local institutions to contact for affordable credit helped them access better credit services.

5.7 Sustainability Assessment

To determine the sustainability of the generation and dissemination of adaptation information and supporting communities to act on information received, the sustainability study focused on four interrelated dimensions.

The first dimension, "**financial sustainability,**" assessed whether financial resources are available to generate adaptation information, to disseminate information in local languages, and to link the households with "action resources" that have the ability to support households to change acquired information into action. This dimension of the assessment included studying farmers' ability and willingness to pay for the climate information services, and a Total Cost of Ownership (TCO) analysis to determine the costs involved in the generation and dissemination of adaptation information and the support of communities to apply information in action.

The second dimension, "**technical sustainability,**" assessed whether or not the CHAI solution meets user needs, is in concordance with the existing ecosystem (such as legal, technological, and regulatory policies), is modular in design allowing its rollout, and if its maintenance and improvements can be supported by government and local private institutions.

The third dimension, "**institutional sustainability,**" assessed the institutional arrangement needed for the generation and dissemination of adaptation information at national, district, sub-county, and village levels.

The fourth dimension, "**social sustainability,**" assessed ease of access of the information services and whether the solution is in accordance with social and cultural preferences and practices.

Summary of the outcomes of the sustainability assessment of the CHAI approach are provided in the following sub-sections.

5.7.1 Financial Sustainability

CHAI project evidence showed the importance of hyper-local climate and agricultural information for improving agricultural productivity and minimizing crop losses due to unfavorable weather and climatic conditions. To increase agricultural production and minimize crop loses, it is imperative that farmers receive climate and agricultural information to help them make decisions about farm investments and management practices before commencement of each planning season. As noted in previous sections of this report, the CHAI project applied an institutional framework involving multiple stakeholders at the national, district, county, and sub-county levels for the generation and dissemination of relevant information and to support farmers in acquiring knowledge and acting upon it. The project instituted mechanisms for daily weather data and weekly crop and livestock market data collection using mobile phones and engaged multiple stakeholders in the delivery of climate and agricultural information localized to the sub-county-level through interactive radio broadcasts in local languages and via mobile phones.

The information system developed by the project can only function if financial resources are available to support the generation and dissemination of information. These costs have been covered by the project, UNMA, which is responsible for the generation of the seasonal, 10-day, and daily weather forecasts, and other implementing partners. However, climate and agricultural information delivery to current users, and expansion of the CHAI model to small-holder farmers nationwide, is not possible without long-term financial support. Data on farmers' willingness and ability to pay for climate information varied markedly between the project's first and second endline surveys. During the survey conducted in September 2016, the average respondent sampled (including respondents from the control district of Rakai) indicated a willingness to pay $7.79/year for all-inclusive climate services.[6]

The average willingness to pay from the 2016 survey for the intervention districts was $6.17/year/household. During a similar survey conducted in September 2017, the amount sampled respondents were willing to pay fell significantly to an average of $2.03/year.[7] The average willingness to pay from the 2017 survey for the intervention districts was $1.97/year/household.

Several factors contributed to the significant reduction in the amount of money respondents are willing to pay from $6.17/year/household in 2016 to $1.97/year/household in 2017. Farmers' willingness to pay for climate information is affected by factors such as perceived risk of loss due to climatic conditions, perceived trustworthiness of information received and how the use of the information will minimize the perceived risks. The reduction in willingness to pay is partly attributed to the perception of some respondents that they were able to predict future weather conditions by themselves using traditional approaches. Focus group discussions with farmers indicated that the traditional markers such as wind direction were observed in 2017 before the start of the season while such markers didn't occur in 2016. The farmers felt confident that rain will come in time and they saw little benefit in paying for climate and agricultural information. This perception reduced the amount of money the farmers were willing to pay in 2017.

[6] By district, the average respondent was willing to pay $12.62/year in Rakai, $9.55/year in Soroti, $4.49/year in Sembabule, and $4.48/year in Nakasongola.

[7] By district, the average respondent was willing to pay $3.06/year in Soroti, $1.47/year in Sembabule, and $1.39/year in Rakai and Nakasongola.

Since risk perceptions and perceived value of climate information vary, taking the average of the two years provides a better estimate of farmers' long-term willingness to pay for information. The intervention districts' average willingness and ability to pay for 2016 and 2017 combined is $4.07/year/household. (Detailed analysis of willingness and ability to pay is provided in previous sections of this report.)

Total Cost of Ownership

A Total Cost of Ownership (TCO) analysis was conducted to determine the costs involved in the generation and dissemination of climate and agricultural information in local languages to small-holder farmers. Details of the TCO model and outcomes of the analysis are provided in the following subsections.

Delimiting Institutions and Costs

TCO calculates the complete cost associated with a product or service from initial investments to disposal. In determining the TCO of a service or product, it is important to establish which institutions must be considered and what cost elements will be included.

Several institutions/units are involved in the generation of information and its dissemination through the CHAI platform. The following inclusion criteria are used in determining which institutions will be considered for TCO calculations.[8]

- Institutions or units involved in the collection of weather and/or market data used for the generation of climate or agricultural information;
- Institutions or units directly involved in the generation of climate and/or agricultural information disseminated through CHAI;
- Institutions or units that provide services for the delivery of information to farmers such as mobile network operators, bulk SMS providers/aggregators and local FM radio stations; and
- Institutions or units whose staff provide extension or advisory services to farmers to enhance the use of information disseminated through the CHAI platform.

The institutions considered for inclusion in the calculation of TCO for climate and agricultural information generation and dissemination, and the provision of support to farmers to use this information include:

[8] Development and testing of the technology and approach used by the CHAI project were led by FHI 360 and UCH in collaboration with implementing partners of the project. Ready for full deployment, scaling the solution will require only minimal and temporary assistance from FHI 360 and UCH. Therefore, the costs associated with these institutions are excluded in calculating the TCO.

Institution / Entity	Role
Uganda National Meteorological Authority (UNMA)	Generate sub-county-level seasonal forecasts, 10-day weather forecasts, agricultural advisories and advisories related to extreme events
District-level Production Department (Ministry of Agriculture and Fishery) and District-level Natural Resources and Environment Department	Localize content generated by UNMA, participate in monthly radio talk-shows, provide ongoing support to farmers through extension agents.
Extension agents	Provide extension services to farmers
Community Development Officers (district-level)	Collect and submit weekly crop and livestock market data from local market outlets using mobile phones
Weather data recorders (sub-county-level)	Collect and submit daily rainfall data using mobile phones
Local FM radio stations	Transmit climate and agricultural information in local languages weekly and host radio talk shows monthly
Mobile network operators	Disseminate climate and agricultural information via text messaging
Bulk SMS providers/aggregators	Broadcast climate and agricultural information in local languages to farmers and support groups

Table 33: Institutions included in total cost of ownership determination

Cost Model

A cost model covering the life-cycle costs of the CHAI system components including the generation and dissemination of adaptation information, equipment acquisition, training, operations, maintenance, and replacement costs was developed using a two-level hierarchical system where costs are allocated to several major categories followed by sub-categories (cost elements). These include:

Category	Cost Element
DISTRICT LEVEL EXPENSES	
Trainings	Initial Training of CDOs, WRs, Extension Agents and district level officers (30% attrition rate assumed for Year-2 onwards)
	Recurring training of CDOs, WRs, Extension Agents and district level officers
	Trainers' expenses
Data Plan and Incentives for market and weather data collectors	Data Plan for market and weather data collection
	Incentives for CDOs and WRs
Equipment and Depreciation (used at district-level)	Android smartphone for CDOs and WRs

	Android smartphone for CDOs and WRs depreciation
Content Dissemination	SMS broadcasts
	FM radio broadcasts
NATIONAL LEVEL EXPENSES	
Salary, server hosting and depreciation	Forecasters / agro-meteorologists' salary
	Server hosting
	Server depreciation

Table 34: TCO costs

Assumptions and Cost Determination Approaches

Actual equipment costs, training expenses, text messaging/SMS charges, FM radio transmission costs, staff salaries, per diem rates for trainers, and incentives for data collectors were used for TCO calculations. The TCO was modelled for a period of five years; the assumptions applied for calculating current and projected costs include:

Description	Quantity/No	Notes
Uganda population	44,490,000	2017 World Bank estimate
Population growth rate	3.1%	
Household (HH) size	4.70	UBOS estimate
Number of districts	122	Includes Kampala
Proportion of farmers	80%	
Unique mobile subscribers in Uganda	17,000,000	Source: GSM Association (GSMA)
Unique subscriber growth rate	6%	Source: GSMA
Yearly inflation rate	4%	
Exchange Rate, US $1 =	3600 UGX	Per OANDA on Feb 3, 2018
Unique mobile subscribers as a percentage of population	38%	Calculated (percentage of the unique subscribers to total population ratio)
Average population per district	364,672	Calculated (ratio of total population to the number of districts)
Average # of HHs per district	77,590	Calculated (ratio of district population to HH size)
Average # of farming HHs per district	62,072	Calculated (80% of HH per district)
Estimated # of farming HHs with mobile phones	23,718	Calculated (38% of farming household)
Number of SMS sent per year	26	SMS messages are sent every two weeks
Number of Community Development Officers (CDO) per district	4	From CHAI pilot deployment
Number of Weather Recorders (WR) per district	4	From CHAI pilot deployment

Districts per forecaster / agro-meteorologist	10	Based on experiences form CHAI pilot deployment
Monthly salary for forecaster / agro-meteorologist in UGX	1,200,000	Actual salary records
Server initial cost	$6,000	Actual server cost
Server depreciation	20%	Assumes server will be replaced in 5 years
Smartphone depreciation	33%	Assumes smartphones will be replaced in 3 years

Table 35: Major assumptions for TCO determination

TCO Calculations for Modeled District and National-Level Expenses

District-Level TCO Calculations

The district-level TCO elements include costs related to the training of data collectors and district-level technical officers on agrometeorology and climate/agricultural information localization to the specific conditions of the district, costs related to market and daily weather data collection, and costs related to the dissemination of information through mobile phones and interactive radio broadcasts.

Training

Training costs include expenses incurred for the training of Community Development Officers (CDO) who are responsible for market data collection using mobile phones from local market outlets; training of weather data recorders who are responsible for collecting daily rainfall data from rain gauges installed at sub-counties using mobile phones; and the training of district-level technical personnel on agrometeorology and localizing climate and agricultural information to sub-counties in the district. The cost calculations assume a 2-day initial training of CDOs and weather recorders, a 1-day refresher training every year, and an attrition rate of 30%. It is further assumed that the district level officers receive an initial 3-day training, a 2-day recurring training offered every year, and an attrition rate of 20%.

District-Level Training	Unit type	# of Units	Cost/unit (USD)	Total cost (USD)
Per Community Development Officer (CDO) - market data collection				
Initial training days	Days/year	2	$80	$160
Recurring training days	Days/year	1	$80	$80
Per Weather Recorder (WR)				
Initial training days	Days/year	2	$80	$160
Recurring training days	Days/year	1	$80	$80
Per Extension Agent				
Initial training days	Days/year	1	$80	$80

Recurring training days	Days/year	1	$80	$80
Per District Level Officer				
Initial training days	Days/year	3	$90	$270
Recurring training days	Days/year	2	$90	$180
Trainer (from UNMA on agrometeorology and market data collection)				
Initial training days	Days/year	8	$200	$1600
Recurring training days	Days/year	5	$200	$1000

Table 36: Training costs

The TCO calculations for training for five years for the modelled district are provided in the following table.

TRAINING COSTS PER DISTRICT/YEAR (in USD)	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Training of CDOs, WRs, Extension Agents and district level officers (30% attrition rate for CDOs and WRs; and 20% for district level officers assumed for Year-2 onwards)	$670	$228	$305	$409	$548
Recurring training of CDOs, WRs, Extension Agents and district level officers	$420	$563	$754	$1,011	$1,354
Trainers per diem and transport ($200/day all-inclusive assumed)	$2,600	$2,704	$2,812	$2,925	$3,042
TOTAL Training Cost Per District	**$3,690**	**$3,495**	**$3,872**	**$4,344**	**$4,944**

Table 37: Training costs per district

Connectivity Costs and Incentives for Data Collectors

Connectivity costs are the amounts paid for data plans (internet services) for the mobile phones used by CDOs and weather recorders. The CDOs are employees of the local (district) government working under the Community Development Department. Market data collection is not their primary responsibility; however, they are invariably willing to collect market prices using mobile phones for additional remuneration. In the three districts where CHAI was deployed, the Community Development Department authorized the CDOs in the district to collect market prices with an additional remuneration of UGX 60,000/month (US $16.67). The weather recorders are based at sub-counties with formal weather data collection training provided by the Uganda National Meteorological Authority (UNMA). The weather recorders are paid a monthly allowance of UGX 60,000/month (US $16.67).

Monthly Connectivity and Incentives	Duration	No	Amount
CDOs: Data plan	monthly	1	$4
CDOs: Additional Incentive (UGX 60,000/month)	monthly	1	$17

Subtotal			**$21**
Weather recorder: Data plan	monthly	1	$4
Weather recorder: Additional Incentive (UGX 60,000/month)	monthly	1	$17
Subtotal			**$21**

Table 38: Monthly connectivity costs and i8ncentives for data collectors

The CHAI project found that the optimum number of CDOs and weather recorders per district is 4 each for weekly market and daily rainfall data collection and submission to the central server through the wireless network. Based on this assumption, the TCO calculations for connectivity and incentives for data collectors is provided in the following table.

DATA PLAN and INCENTIVES per District	Year 1	Year 2	Year 3	Year 4	Year 5
Data plan for CDOs and WRs	$384	$399	$415	$432	$449
Incentives for CDOs and WRs	$1,600	$1,664	$1,731	$1,800	$1,872
TOTAL Data Plan and Incentives for Data Collectors Per District	**$1,984**	**$2,063**	**$2,146**	**$2,232**	**$2,321**

Table 39: Yearly connectivity and data collectors' incentives per district

Equipment Cost

Costs for smartphones used by the CDOs and weather recorders for data collection and the related depreciation costs are included in the TCO model. Entry-level Android smartphones that cost about $100 were used for data collection. An attrition rate of 30% is assumed for the CDOs and weather recorders. It is further assumed that new CDOs and weather recorders replacing staff who left will receive new smartphone because it is often very difficult to get a phone back in working conditions from departing staff.

District-Level Equipment Cost and Depreciation	Year 1	Year 2	Year 3	Year 4	Year 5
Android smartphone for CDOs and WRs (attrition rate of 30% assumed; new staff receive new smartphone)	$800	$272	$304	$336	$368
Android smartphone depreciation	$267	$277	$288	$300	$312
Total District-Level Equipment Cost and Depreciation	**$1,067**	**$549**	**$592**	**$636**	**$680**

Table 40: Yearly equipment and depreciation costs per district

Information Dissemination Costs

Climate and agricultural information is primarily disseminated through text messaging and local (district-based) interactive FM radio transmission. Text messages were broadcast to farmers every two weeks. Interactive FM radio transmissions included a monthly one-hour talk show, six broadcasts of seasonal weather forecasts and agricultural advisories (2 seasons/year, 3 broadcasts/season); and 18 broadcasts of 10-days weather and agricultural advisories (180 days during 6 in-season months, 1 broadcast every 10 days). Participants of the radio talk show include district-level officers from the local government, community leaders and local politicians; participation is voluntary and receives no financial remuneration.

The rates for SMS dissemination are taken from the actual amounts paid through the CHAI project. The costs included monthly sender ID charges (USSD aggregation fee) paid as a lump sum ($97/month) and per outgoing message rate of $0.01/message.

SMS dissemination per district	Year 1	Year 2	Year 3	Year 4	Year 5
SMS Broadcast	73,111	80,352	85,216	90,261	95,604

Table 41: Yearly SMS dissemination cost per district

The monthly and yearly rates for FM radio broadcasts are provided in the following table.

Radio talk shows and broadcasts	No./Year	USD/month	USD/year
Monthly radio talk show for 1 hour	12	$194	$2,333
Seasonal weather forecast and agricultural advisories (3/season; 2 seasons/year)	6	$69	$833
10-day weather forecast and agricultural advisories (6 months x 30 days = 180 days -> 18 broadcasts	18	$28	$333
Total Radio Broadcast		**$292**	**$3,500**

Table 42: Radio talk show costs

Radio broadcast costs per district adjusted for inflation for a period of five years is provided below.

Radio talk shows and broadcast per district	Year 1	Year 2	Year 3	Year 4	Year 5
Radio broadcasts	$3,500	$3,640	$3,786	$3,937	$4,095

Table 43: Yearly radio talk show costs per district

Summary of the district-level TCO are provided in the following table.

DISTRICT LEVEL TCO PER DISTRICT	Year 1	Year 2	Year 3	Year 4	Year 5
Training	$3,690	$3,495	$3,872	$4,344	$4,944

Data Plan and Incentives for Data Collectors	$1,984	$2,063	$2,146	$2,232	$2,321
District-Level Equipment Cost and Replacement	$1,067	$549	$592	$636	$680
SMS Broadcast	$73,111	$80,352	$85,216	$90,261	$95,604
Radio Broadcasts	$3,500	$3,640	$3,786	$3,937	$4,095
Total	**$83,352**	**$90,099**	**$95,612**	**$101,410**	**$107,644**

Table 44: Summary of annual district-level costs

National-Level TCO Calculations

The national-level costs include the expenses for maintaining components of the system that provide service to all districts. Costs included in this category include server hosting, server replacement, and salaries for weather forecasters and agro-meteorologists who generate climate and agricultural information for localization by the districts and dissemination to farmers. The national-level staff also provide training to district-level technical officers. While costs related to the per diem and subsistence allowances for national trainers are modelled under district-level expenses, their salaries are listed under this category.

The national-level costs are provided in the following tables.

NATIONAL LEVEL STAFF	No.	Monthly Rate (UGX)	USD/month	USD/year
Forecasters/ agro-meteorologist salary	12	1,200,000	4,067	48,800
Total National Level Staff (content generation and training)		**1,200,000**	**4,067**	**48,800**

Table 45 National-level staff costs

Server hosting	UGX/month	USD/month	USD/year
Domain hosting per month	19,500	$5	$65
Public IP address	9,750	$3	$33
Internet subscription (Vodafone published rates, 10mbps)	349,900	$97	$1,166
Total server hosting	**379,150**	**$105**	**$1,264**

Table 46: Server hosting costs (national level)

The following table shows the national-level expenses per district.

NATIONAL LEVEL EXPENSES per District	Year 1	Year 2	Year 3	Year 4	Year 5
Forecasters / agro-meteorologist's salary	$48,800	$50,752	$52,782	$54,893	$57,089
Server hosting	$1,264	$1,314	$1,367	$1,422	$1,479
Server depreciation	$1,200	$1,248	$1,298	$1,350	$1,404
TOTAL NATIONAL LEVEL EXPENSES	***$51,264***	***$53,314.39***	***$55,447***	***$57,665***	***$59,971***
TOTAL NATIONAL LEVEL EXPENSES PER DISTRICT	**$420**	**$437**	**$455**	**$473**	**$492**

Table 47: National-level costs per district

Total Cost of Ownership for Five Years

The costs enumerated in the previous section were aggregated to provide the total cost of ownership per district for the following scale of operations per district. The number of households for each year is based on current Uganda population, population growth rate, existing number of mobile subscribers and subscriber growth rate (provided under the "Assumptions and Cost Determination Approaches" section of this report).

Scale of Operations PER DISTRICT	Year 1	Year 2	Year 3	Year 4	Year 5
Number of farming households accessing climate and agricultural information using mobile phones	23,718	25,141	26,649	28,248	29,943
Number of farming households accessing climate and agricultural information through FM Radio	62,072	65,796	69,744	73,929	78,365

Table 48: Scale of operations per district

The total per district assuming the system is rolled out nationwide and assuming all farming households receive climate and agricultural information through text messaging (one person per household) is provided in the following table.

TOTAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL	AVERAGE / YEAR
Trainings	$3,690	$3,495	$3,872	$4,344	$4,944	$20,344	**$4,069**
Data plan and incentives	$1,984	$2,063	$2,146	$2,232	$2,321	$10,746	**$2,149**
Equipment and Depreciation	$1,067	$549	$592	$636	$680	$3,524	**$705**

SMS Dissemination	$73,111	$80,352	$85,216	$90,261	$95,604	$424,544	**$84,909**
FM radio broadcasts	$3,500	$3,640	$3,786	$3,937	$4,095	$18,958	**$3,792**
Salary, server hosting and depreciation	$420	$437	$454	$473	$492	$2,276	**$455**
TOTAL COST OF OWNERSHIP PER DISTRICT	**$83,772**	**$90,536**	**$96,066**	**$101,883**	**$108,136**	**$480,392**	**$96,078**

Table 49: Total cost of ownership per district

Text messaging is the largest cost element (87%) followed by training costs (5.7%), interactive radio broadcasts (3.9%), connectivity (data plan) for market and weather data collection, incentives for data collectors (2.2%), smartphone cost used at district level and their replacement (0.7%) and national-level expenses for salary, server hosting and replacement (0.5%).

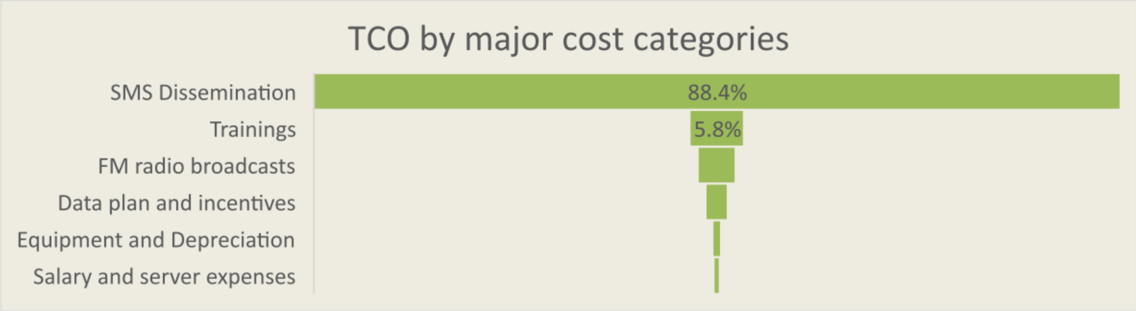

Figure 22: Total cost of ownership by major cost elements

Assuming all farming households receiving information through text messaging pay for the services, the total cost of ownership per household for the modelled district is provided in the following table.

Average Yearly Costs for Modelled District	Year 1	Year 2	Year 3	Year 4	Year 5	ANNUAL AVERAGE	%
SMS broadcasts	$3.08	$3.20	$3.20	$3.20	$3.19	$3.17	88.35%
Trainings	$0.16	$0.14	$0.15	$0.15	$0.17	$0.15	4.23%
FM radio broadcasts	$0.15	$0.14	$0.14	$0.14	$0.14	$0.14	3.96%
Data Plan and Incentives for weather data collectors[9]	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	2.24%

[9] Subcounty-based weather data collectors are volunteers. UNMA trained the data collectors and UNMA pays them 60,000 UGX (about US $16.67) per month as an incentive.

Equipment and Depreciation	$0.04	$0.02	$0.02	$0.02	$0.02	$0.03	0.75%
Salaries for Forecasters / Agro-meteorologists	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	0.45%
Server hosting	$0.0004	$0.0004	$0.0004	$0.0004	$0.0004	$0.0004	0.01%
Server depreciation	$0.0004	$0.0004	$0.0004	$0.0004	$0.0004	$0.0004	0.01%
AVERAGE PROJECTED COSTS (per Household)	**$3.53**	**$3.60**	**$3.60**	**$3.61**	**$3.61**	**$3.59**	**100%**

Table 50: Total cost of ownership per household assuming full national rollout of CHAI

The CHAI project disseminated information using SMS and FM radio to all farming households in three districts. The TCO per district at the current operational level (i.e., CHAI deployed to 3 intervention districts) using the calculated five-year average is provided in the following table.

Cost Element	Amount	Percentage	TCO / Household
SMS dissemination	$84,909	88.37%	$3.58
Trainings	$4,069	4.23%	$0.17
FM radio broadcasts	$3,792	3.95%	$0.16
Data plan and incentives	$2,149	2.24%	$0.09
Equipment and depreciation	$705	0.73%	$0.03
National-level expenses	$455	0.47%	$0.02
Total per district	**$96,078**	**100.00%**	**$4.05**

Table 51: Total cost of ownership of CHAI at the current operational level (CHAI deployment at 3 districts)

As noted earlier in this report, the willingness and ability to pay for climate and agricultural information by farming households, on average, is $4.07/year. Assuming all farming households pay for the service, the amount households are willing to pay almost equals the TCO per household ($4.05). However, the endline survey of CHAI-II showed that only 35% of the respondents were willing to pay for the services. To determine the minimum proportion of the households willing to pay for the services to recoup the total cost of ownership, the per household cost for different proportions of households willing to pay was computed. The following table shows the TCO per household for different proportions of farming households willing to pay for services for the current level of operation of the CHAI project (i.e., deployment in three districts).

Percentage of households willing to pay	TCO per household
100%	$4.08
90%	$4.54
80%	$5.10
70%	$5.83
60%	$6.81

50%	$8.17
40%	$10.21
35%	***$11.67***
30%	$13.61
20%	$20.42
10%	$40.83
5%	$81.66

Table 52: TCO per household for different proportions of the households willing to pay for services. If only 35% of the households pay, each household must pay $11.67/year to recoup costs for the generation and dissemination of climate and agricultural information.

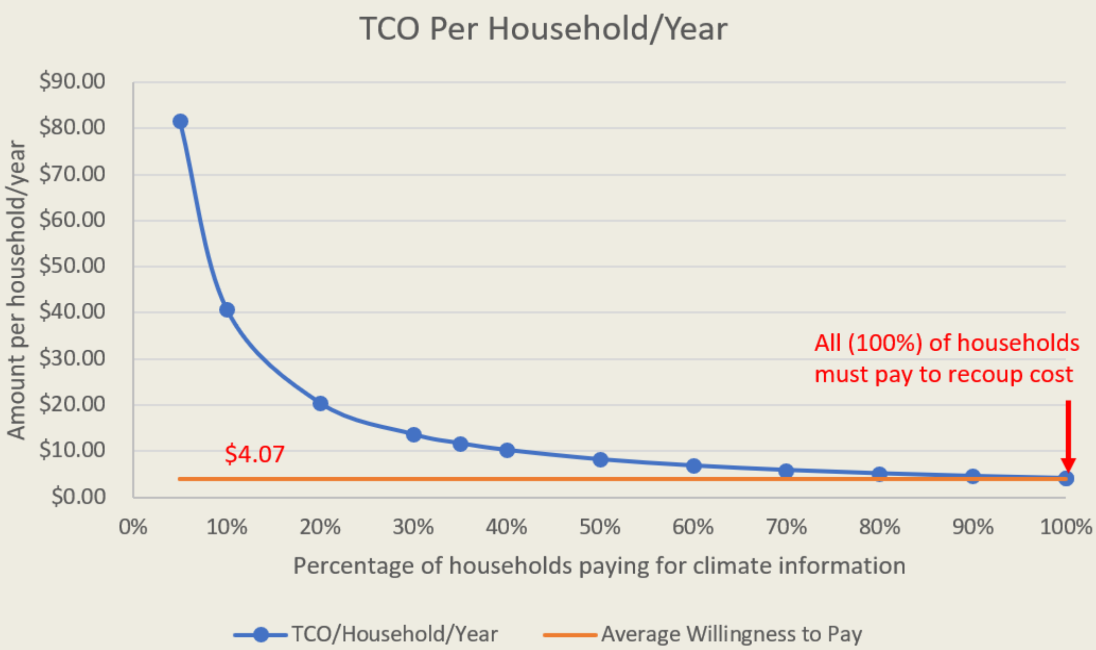

Figure 23: TCO per household for different proportions of households paying for services for current CHAI level of operation (3 districts). Horizontal red line shows the average amount farming households are willing to pay.

As shown in the table provided above, for the scenario where only 35% of the farming households are willing to pay (CHAI-II endline survey), the average TCO per household per year is $11.67 which is $7.60 higher than the average maximum amount households are willing to pay ($4.07). To fully recover the costs for the generation and dissemination of climate and agricultural information, assuming the system is deployed to three districts, 100% of the household must be willing and able to pay at a rate of $4.07/household/year or the difference needs to be covered by the government and/or support organizations.

The calculated average TCO per household in a nationwide deployment is compared with TCO per household for a three-district rollout (current CHAI operational level) in the following table.

Percentage of user paying for services	TCO per household (national rollout)	TCO per household (3 districts rollout)	Saving per household from national rollout
100%	$4.05	$4.08	$0.10
90%	$4.50	$4.54	$0.11
80%	$5.06	$5.10	$0.12
70%	$5.78	$5.83	$0.14
60%	$6.75	$6.81	$0.16
50%	$8.10	$8.17	$0.19
40%	$10.12	$10.21	$0.24
35%	$11.57	$11.67	$0.27
30%	$13.50	$13.61	$0.32
20%	$20.25	$20.42	$0.48
10%	$40.49	$40.83	$0.96
5%	$80.99	$81.66	$1.91

Figure 24: Total cost of ownership per household for nationwide rollout and current CHAI operational level (3 districts)

As shown in the table, the difference in per household TCO between a national rollout and a three-district operational level varies between $0.10/household if all households pay for services to $1.91/household if only 5% of the household pay for services. This is because, as shown in the following table, district-level expenses constitute over 99% of the total cost of ownership.

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Average
District-level TCO (only district-level expenses)	$83,352	$90,099	$95,612	$101,410	$107,644	$95,623.40
National-level TCO (expenses incurred at national level to support districts)	$420	$437	$454	$473	$492	$455.20
Total TCO per district	$83,772	$90,536	$96,066	$101,883	$108,136	$96,078.60
Proportion of district-level expenses	**99.5%**	**99.5%**	**99.5%**	**99.5%**	**99.5%**	**99.5%**

Figure 25: Proportions of District and national-level components of the TCO

As shown in Figure 22, the average total cost of ownership of the CHAI climate and agricultural information service ***per district is $96,079/year*** and ***TCO for expanding the solution nationwide is $11,721,638/year***.

Key conclusions from the TCO Analysis

Scaling up or "*expanding, replicating, adapting and sustaining successful policies, programs or projects in geographic space and over time to reach a greater number of people*" can follow different pathways (Hartmann and Linn 2008). The scaling up pathway may also involve "horizontal" expansion of the solution from the pilot districts to other districts; or "vertical" scaling up which may involve expanding the solution nationwide. For scaling up the climate and agricultural information service developed by the project, the "horizontal pathway" would require the investment for expanding the solution from district local government, and the "vertical pathway" would require that the funding and/or the coordination for bringing the funding required for expansion is done by the national government.

District local government-led "horizontal" scale up pathway: Over 99% of the costs for the generation and dissemination of climate and agricultural information is incurred at the district-level. In countries where authority is centralized, the bulk of the costs can be at the national level. However, in countries like Uganda where the local government has the mandate to budget for most of its programs, the role of the local government is vitally important in expanding the delivery of climate and agricultural information. The average budgetary requirement for scaling up the climate and agricultural information service per district is about $96,079. If this pathway is followed, each district can fund the expansion of the solution in coordination with the Uganda National Meteorological Authority (UNMA).

National government-led "vertical" scale up pathway: For a national rollout, the total cost of ownership is about **$11,721,638/year**. The budgetary requirement for national rollout is significant, but the national government (through UNMA) may play a coordination role to collect contributions from participating districts. With this approach, each district will be responsible for signing contracts with local FM radio stations for radio-based information dissemination, and UNMA will be responsible for mobile phone-based information dissemination through bulk SMS providers.

It is recommended that a workshop involving district local government, UNMA, Climate Change Department and other players be held to discuss on the horizontal and vertical scaling up pathways and determine which route to pursue for Uganda.

Financing options: The generation and dissemination of climate and agricultural information can be fully funded by the farmers receiving the information only if 100% of the farming households accessing climate information through mobile phones are able and willing to pay for the services at $4.05/household. However, the study showed that only 35% of the respondents were willing to pay. As farmers see the value of the information service, their willingness to pay will likely increase through time. It is recommended that the government (local and national) fund the scale up of the solution as part of its mandate to provide actionable climate and agricultural information to farming households. The main funding sources and instruments for the government include the Uganda National and Sectoral Development Plans and Budgets as different departments of the government are required to budget for climate change related activities. The other significant source of funding for the government is from bilateral and multilateral development partners support and from international climate change funds. Public-Private Partnerships that entail agreements between the government and mobile network operators for financing the dissemination of climate and agricultural information is another important financing option.

As shown in the TCO analysis, over 88% of the budgetary requirement is for supporting the dissemination of information via SMS. The analysis shows that a 10% reduction in the cost of sending/receiving SMS messages reduces the total cost of ownership by close to 9%. For example, if the bulk SMS provider reduces the current per outgoing SMS message rate of 35 UGX (US $0.01) by 10% (making the rate per outgoing SMS message 31.5 UGX), the annual total cost of ownership will reduce from $11,721,638/year to about $10,690,134/year. In other words, each 10% reduction in the per outgoing SMS rate will result in the reduction of over $1 million in the annual total cost of ownership of the system. It is imperative that the Ministry of Water and Environment negotiates with mobile network providers to reduce the rates associated with the delivery of information via SMS. The mobile network operators indicated their interest to negotiate favorable rates with pertinent bodies of the government.

User contribution can be introduced at a time when adequate demand has been created and when most of the farmers have experienced the value of the service. It is also recommended to carry out annual willingness and ability to pay survey to assess changes in the perception of farmers on the importance of the climate and agricultural information service.

5.7.2 Institutional Sustainability

Institutions are defined as the “rules or procedures that shape how people act, and roles or organizations that have attained special status or legitimacy” (Brinkerhoff and Goldsmith, 1992:371). Institutions can be formal, such as rules that people devise, or informal, such as conventions and codes of behavior. Whether explicit or implicit, institutions have a significant role in shaping performance and longevity of initiatives. Institutional sustainability refers to the capacity of an institution to generate a minimum level and quality of *valued outputs over the long term* (Brown, 1998, Brinkerhoff and Goldsmith, 1992, and Pfahl, 2005).

For the CHAI project, the *valued outputs* that must be sustained over a long term are the generation, dissemination, and supporting the use of climate and agricultural information. To meet this objective, the project established an elaborate institutional framework at national, district, and sub-county levels. At the national level, the CHAI project is integrated with the routine business processes of the Uganda National Meteorological Authority (UNMA) and the Climate Change Department, Ministry of Water and Environment. At the district level, the processes of generation and dissemination of climate and agricultural information are integrated with the various technical departments (Production, Natural Resources, Water, Commerce and Community Development). The project has demonstrated some level of integration with the Ministry of Agriculture, Animal, Industry, and Fisheries, however, this requires further strengthening.

Details on the institutionalization of the CHAI approach within the various institutions at the national and district levels are provided in the following sub-sections.

National Level

Uganda National Meteorological Authority

The Uganda National Meteorological Authority (UNMA) is a semi-autonomous government institution for weather and climate services under the Ministry of Water and Environment and a focal institution to the Inter-Governmental Panel on Climate Change (IPCC). Its mandate includes monitoring of weather and climate as well as providing weather predictions and advisories to government bodies, farmers, and other stakeholders for promoting the sustainable development of the country. This is operationalized through strategic objectives to improve the quantity and quality of meteorological services; build a skilled and motivated workforce; promote greater awareness of the benefits of using meteorological services and improve the accuracy and reliability of forecasts and advisory services. Among UNMA's functions is the provision of meteorological and climatological services to weather dependent sectors such as agriculture and maintenance of an efficient communication system for rapid collection and dissemination of meteorological information. Among UNMA's several directorates, the Directorate of Weather Forecasting Services is responsible for the collection and distribution of real-time weather information as well as producing daily public and aviation forecasts; the Directorate of Networks and Observations ensures the performance, effectiveness, and efficiency of UNMA operations; the Directorate of Applied Meteorology, Data, and Climate Services is responsible for data, research, and liaison with the public; and the Directorate of Training and Research is responsible for capacity building and motivating staff to achieve the organization's strategic objective. UNMA is ISO certified with ISO 9001:2008 certification in aeronautical meteorology.

UNMA and CHAI have shared mission and ambition to provide timely and accurate climate and agricultural information to farmers in Uganda. UNMA and CHAI have strong audience alignment as both target small-holder farmers as the users of their services. CHAI objectives are embedded in the strategic objectives and the mandate of UNMA and efforts for scaling up the CHAI approach nationwide can make use of UNMA's infrastructure. Because of this, UNMA is the most suitable entity to host and scale up the CHAI approach nationwide. Towards this end, the CHAI project has maintained a close collaboration with UNMA since its inception in 2012.

UNMA and CHAI assessed the key factors that impede UNMA's ability to generate accurate localized seasonal forecasts for minimizing the impacts of droughts. These include the limited numbers of weather stations for gathering observational rainfall data and delays in transmitting data from weather stations to the UNMA for analysis. There were only 12 functional rain gauges in the intervention districts (Nakasongola, Soroti, and Sembabule) while the requirement for making sound seasonal forecasts was 22 rain gauges. To ameliorate this impediment, the project and the Meteorology Authority installed 10 new rain gauges at the sub-county level in the three districts. The weather data collection and reporting system developed by the project supports the collection of daily weather data on mobile devices, the transmission of the data via the cellular network to a server installed at the UNMA headquarters in Kampala, and the transference of the data to weather forecast applications used by the Authority's Directorate of Weather Forecasting Services.

To support the full takeover of the CHAI approach by UNMA, the project acquired, configured, and installed a Dell PowerEdge model T320 tower server at UNMA headquarters. The server hosts a database for storing and exchanging weather and market data transmitted via the cellular network from the mobile devices deployed in the intervention districts. The server application developed by the project includes a web-based dashboard interface to allow for data export, report generation, and visualization; facilitation of real-time data transfer from remotely located mobile devices; and deployment of new or updated data collection forms to mobile devices in the field.

District-based meteorology weather station data recorders based at sub-counties were trained on using mobile phones for collecting and transmitting daily weather data. A total of 22 trained weather data recorders collected rainfall data using Android devices provided by the project and transmitted the data to the server installed at UNMA in Kampala daily. The availability of daily rainfall data from sub-counties has enabled the Meteorology Authority to continuously correct forecasts generated by different models; produce better seasonal forecasts that are vitally important for the agro-pastoral communities to take appropriate adaptation responses; and generate localized forecasts that are more relevant for the sub-counties. UNMA has started adopting the approach tested by the project which involves the training of subcounty-based weather data recorders on the use of mobile phones for the capture and submission of daily weather data. The data recorders are volunteer and to ensure continuity of service, UNMA paid them a monthly remuneration of 60,000 UGX (about US $16.67) as an "incentive". UNMA has started allocating budget for paying weather recorders' monthly incentives and during the 2016/17 fiscal year, UNMA budgeted incentives for 50 weather data recorders who were engaged in the collection and submission of daily weather data.

To support the national scaling of the climate and agricultural information service, the recommended changes at UNMA include the following.

Expand observational networks: The availability of well-maintained and dense observational networks for weather and climate is of critical importance for seasonal forecasting and other weather-dependent sectoral applications especially for the agriculture sector. UNMA assessments show that, currently, out of 20 agrometeorological zones in Uganda, only 8 have observation stations; out of 20 hydro-meteorological zones, only 6 have observation stations; out of 16 synoptic zones, only 12 have observation stations; out of 600 rainfall zones, only 150 have stations. As a temporary measure, the project working with UNMA installed 22 rain gauges at subcounty level at the intervention districts. However, to generate reliable seasonal and 10-day weather forecasts and agricultural advisories localized to subcounty-level, UNMA needs to make significant investments to expand its observational network coverage. The ideal solution is the installation of automatic weather stations (AWS), however, initial costs associated with purchase, installation, and maintenance are lower for manual instrumentation and UNMA have identified priority areas for AWS. In areas where manual instrumentation is installed, it is recommended that UNMA use the mobile application developed by the project for capturing daily weather data and submitting it to the server installed by the project at UNMA in Kampala. Both automatic and manual weather stations would require an attendant and UNMA needs to hire and train subcounty-based weather records/attendants who will be responsible for recording data and/or the upkeep of weather stations.

Strengthen human resources: The generation of location-specific climate and agricultural information requires a dedicated team of weather forecasters and agro-meteorologists. The number of forecasters and agrometeorology during the study was only 4, which is way below the required number. It is recommended to bring the number of forecasting and agrometeorology team to 12 – 14 to enable them to generate subcounty specific seasonal forecasts and agricultural advisories. Uganda is delineated into 16 climatological zones based on principal component analysis (Basalirwa1995). Each of the climatological zones have their own characteristics and it is recommended that each of the forecasters are assigned to specific zone(s) to enable them to improve the accuracy of forecasts through iterative model selection.

Climate Change Department

Climate Change Department (CCD) was established in 2008 with the objective of strengthening Uganda's implementation of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. In January 2014, the Ugandan Cabinet adopted and approved the first Uganda National Climate Change Policy (UNCCP). The principal objective of the UNCCP "is to ensure that all stakeholders address climate change impacts and their causes through appropriate measures, while promoting sustainable development and a green economy." The guiding principles for the formulation of the policy framework include mainstreaming and coordinating response to climate change; communicating effectively and promoting participatory approaches; promoting community-based approaches to adaptation; devoting adequate attention to capacity development and institutional set-ups; devoting adequate attention to technology needs, development, and transfer; identifying, developing, and influencing financing mechanisms; and providing a credible delivery structures.

The Ugandan Constitution provides a regulatory framework for the implementation of the Policy. Based on this mandate, the policy outlines the institutional arrangements for the implementation of the policy. The national coordination function is assigned to the CCD at the Ministry of Water and Environment. The functions of the CCD include acting as the national clearinghouse on climate change; providing policy and strategic advice on climate change; supporting communication and outreach on climate change; providing guidance on the integration of climate change concerns into overall national planning through coordination with the relevant ministries, departments, and governmental agencies; monitoring the implementation of the Policy and its strategy; and serving as the National Focal Point for the UNFCCC.

To meet its objective of serving as the national clearing house for climate change-related information, the CCD in collaboration with the National Planning Authority has developed the national Green Growth Development Strategy for Uganda through a multi stakeholder consultative process. The CCD is completing the development of a web-based National Knowledge Management System for the National Climate Change Resource Center; and has completed prototypes of an eLearning platform, eLibrary, discussion forums, social media support tools, and tools for facilitating webinars. These resources are designed to serve as a knowledge base for supporting climate change mitigation and adaptation actions.

The project has been using the CCD's eLibrary as the source of climate information for dissemination to small holder farmers in the intervention districts. The Knowledge Management System of the CCD will serve as a perpetual source of climate information for the CHAI system and forms one of the pillars that will sustain the CHAI approach after the phaseout of funding. However, the eLibrary has limited number of resources that are locally developed and content that can be used by less educated rural smallholder farmers. The few locally developed resources in the eLibrary are "expert-driven" that are entirely developed by subject matter experts in climate change and agriculture. Most of the content in the eLibrary need to undergo through a localization process to ensure that content is tailored to fit the local context, adapted into local languages and produced in a way that engages smallholder farmers.

Addressing the lack of locally relevant climate and agricultural content is critical to ensuring that the transformative potential of this approach is fully maximized by smallholder farmers. Towards this end, *it is recommended that the CCD introduces an elaborate content curation approach for selecting, organizing, localizing, and presenting climate information in a way that is meaningful to smallholder farmers*.

The Uganda National Climate Change Policy and Uganda five-year National Development Plan (2015/16–2019/20) emphasize the need to institute an organizational structure to address climate change issues at national and local levels. Towards this end, the UNCCP (2018) have an organizational structure approved by parliament for coordinating climate change activities at national and local levels. At the national level, the coordinating body is the Policy Committee on Environment chaired by the prime minister and where the Ministry of Water and Environment through the CCD serves as the secretariat. This body is advised by the National Climate Change Advisory Committee which is chaired by the Ministry of Water and Environment with the CCD serving as the secretariat. Each ministry is expected to have climate change focal person or desk and coordinated by the Ministry of Planning and Ministry of Finance at the national level. At district local government level, climate change activities are coordinated by the District Environment Committee chaired by the Chief Administrative Officer with the district Natural Resources and Environment officer serving as secretariat. All district-level technical departments are a member of the Environment Committee. The project strengthened the Environment Committee at the intervention districts by regularizing the monthly meetings and clearly articulating the roles of Production, Commerce and Natural Resource and Environment departments which included localizing content, supporting face to face meetings with farmers and serving as focal points for the project. As indicated in the previous sections of this report, the district Environment Committees played a crucial role in streamlining the localization and delivery of climate and agricultural information in the district. To support the sustainability and scale up of the climate and agricultural information system, the Environment Committee at district levels must be strengthened.

Based on the foregoing, it is recommended that the CCD engage the national Policy Committee on Environment, the National Climate Change Advisory Committee, the Ministry of Planning and Ministry of Finance to budget for the national rollout of the ICT-based climate and agricultural information system. It is also recommended that the CCD provide an ongoing support to district local governments to establish and operationalize the district Environment Committee.

Ministry of Agriculture, Animal Industry and Fisheries

The Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) is charged with creating an enabling environment for the agricultural sector in the country. Its mandate is to *"promote and support sustainable and market oriented agricultural production, food* *security and household incomes*". The ministry is also responsible for the *"enhancement of crop production and productivity, in a sustainable and environmentally safe manner, for improved food and nutrition security, employment, widened export base and improved incomes of the farmers*".

MAAIF's broad mandate is to formulate, review, and implement national policies, plans, strategies, regulations, and standards and enforce laws, regulations, and standards along the value chain of crops, livestock, and fisheries; control and manage epidemics and disasters and support the control of sporadic and endemic diseases, pests, and vectors; Regulate the use of agricultural chemicals, veterinary drugs, biological, planting, and stocking materials as well as other inputs; support the development of infrastructure and use of water for agricultural production along livestock, crop, and fisheries value chains; establish sustainable systems to collect, process, maintain, and disseminate agricultural statistics and information; support provision of planting and stocking materials and other inputs to increase production and commercialization of agriculture for food security and household income; develop public infrastructure to support production, quality / safety assurance, and value-addition along the livestock, crop, and fisheries commodity chains; monitor, inspect, evaluate, and harmonize activities in the agricultural sector including local governments; strengthen human and institutional capacity and mobilize financial and technical resources for delivery of agricultural services; and develop and promote collaborative mechanisms nationally, regionally, and internationally on issues pertaining to the sector.

To meet its wide-ranging objectives, MAAIF is organized along multiple directorates which include: Animal Resources, Crop Resources, and Departments for Planning, Finance and Administration. The ministry has specialized units and agencies which include: National Agricultural Advisory Services (NAADS), National Agricultural Research Organization (NARO), National Animal Genetic Resource Centre and Data Bank (NAGRC&DB), Coordinating Office for the Control of Trypanosomiasis in Uganda (COCTU), Diary Development Authority (DDA), Uganda Coffee Development Authority (UCDA), and Cotton Development Organization (CDO).

There is a strong alignment between the objectives of the CHAI project and MAAIF especially with NARO and district-level NAADS. The project activities at district-level are intimately interlinked with the extension services provided by NAADS. Despite the imperative for closely working with NARO, the integration of activities between the project and NARO was minimal and is an area for improvement. The levels of integration between the project activities with NAADS and NARO are described below.

National Agricultural Advisory Services

The NAADS is a public agency under MAAIF with a mandate to increase access by all categories of farmers to agricultural inputs for improved household food and nutrition security and household incomes in line with the country's Agricultural Sector Strategic Plan and National Development Plan within Uganda's Vision 2040. NAADS provides support to farmers in the district local governments through its extensive extension services and provision of planting materials (such as seeds and fertilizers) and stocking materials for the livestock sector.

The CHAI project is highly integrated with the services provided at the district level. CHAI activities at the districts are coordinated by the Environment Committee where the district NAADS coordinator is a member. The NAADS coordinator, together with the district Production Officer and Environment Officer are responsible for localizing climate and agricultural information generated by UNMA and the project to local languages and context. The NAADS extension workers receive climate and agricultural information disseminated by the project and base their advisory services to the farmers on such information. The information disseminated by the project includes, among others, what type of crop to plant during the season. Most of the farmers receive the seeds and seedlings recommended by the project from NAADS. Overall, the activities of the project and district-level NAADS are fully integrated.

National Agricultural Research Organization

The National Agricultural Research Organization is the apex body for guidance and coordination of all agricultural research activities in the national agricultural research system in Uganda. NARO is mandated to support the generation of yield-enhancing technologies as stipulated in the National Agricultural Research Act 2005. Its mandate includes to coordinate, oversee, and guide agricultural research in Uganda and its mission is to generate and disseminate appropriate, safe, and cost-effective technologies.

NARO sets national priorities and harmonizes the agricultural research activities of the national agricultural research system, constituent institutions and public agricultural research institutes, civil society organization, and private sector and farmer organizations. It advises and coordinates formulation of policy and legislative proposals, research standards, codes of ethics, conduct, and practice. Promoting the delivery of high quality, efficient agricultural research services through the provision of guidelines and guidance, NARO coordinates and promotes cooperation and collaboration between Uganda and other countries, institutions, scientific or professional societies, and other agricultural research service providers, about agricultural research, development and technology transfer in the agricultural sector to optimally utilize agricultural resources and improve production capacity of such resources.

We note that overall NARO's role is limited to technology generation and not dissemination; and CHAI role is dissemination of technology that are suitable for current climatic conditions. As such, NARO and CHAI are natural allies and their integration serves the purposes of both initiatives. However, the linkage between NARO the CHAI initiative was weak. A key recommendation is to actively engage NARO to facilitate the dissemination of proven agricultural technologies to the farmers through the CHAI platform.

District Local Government Level

The Local Government Act 1997 provides the structure under which all forms of local government including districts and urban authorities are run and managed. Organizationally, district local governments are organized under ten departments and two units: Administration Department; Finance and Planning Department; Engineering and Works Department; Production Department; Commerce and Industry Department; Education Department; Health Department; Community Based Services Department; Natural Resources Department; Planning Department; Internal Audit Unit; and Procurement and Disposal Unit. The departments and units are led by the district Chief Administrative Officer (CAO) who is responsible for overseeing public services in the district and providing strategic leadership in developing, reviewing, monitoring, and implementation of policies, plans, strategies, and programs of the central government and District Council.

According to Uganda's Climate Change Policy, the climate change focal person at the district is the Natural Resources Department. All departments are required to integrate climate change issues into the district development plans. Such integration is overseen by the Environment Committee whose members include all department and unit heads and is chaired by the CAO.

The most pertinent departments for integrating CHAI into district development plans are the Production, Natural Resources, Commerce, and Community Based Services. The Production department is responsible for the use of improved production technologies, expanding effective extension services, farmer training and capacity building, enhancing market-oriented farming, and value addition to agricultural commodities. As the focal point for climate change-related issues, the Natural Resources department's mandate includes ensuring sustainable natural resource use and management in the district. The Commerce and Industry department's responsibilities include improving market linkages including the collection and dissemination of market prices to farmers and value chain actors. The Community Based Services department is responsible for the mobilization and sensitization of the community to enhance their participation in the district development activities.

District-based CHAI activities are fully integrated with the district-level local government structures. Climate and agricultural information from CHAI and UNMA are shared with the Environment Committee and members of the committee discuss and agree on modalities of localizing the information, sharing it with farmers, and engaging the extension infrastructure in the district (including NGOs and CBOs) to support farmers to act on received information. Specific tasks are assigned to the Production department to engage its extension services in the dissemination of information and supporting farmers to apply it. The Community Based Services was responsible for collecting weekly market prices through its sub-county-based Community Development Officers (CDO) using smartphones provided by the project. The Commerce department was responsible for compiling weekly market prices in issue bulletins for display in public places.

Key informant interviews conducted at districts show the level of integration of CHAI project activities into district work and budget plans. The findings show that the intervention districts had functional Environment Committees that were responsible for the localization of climate and agricultural information disseminated by CHAI. Members of the committee were actively engaged in streamlining the activities of CHAI to the respective departments. They participated in planning of climate change adaptation activities and dissemination of information to farmers. The committee members have been conducting radio talk shows in concert with the CHAI team.

A member of the Environment Committee in Nakasongola district note: *"When you talk about CHAI in Nakasongola district, everyone knows that high quality climate and agricultural information is obtained from CHAI. We have established a District Environment Committee responsible for packaging content from CHAI to the specific conditions of our district and translating it to local languages. The committee has been doing the talk shows and is involved in budgeting CHAI activities as part of our district development plan. This is how we have integrated CHAI activities into the Local government plan."* A member of the Environment Committee in Soroti district shared similar insights about CHAI, noting that they *"have developed a climate change adaptation plan. The committee has also developed an implementation plan for mainstreaming CHAI activities into the activities designed to respond to climate change."*

There are no offices or personnel under the district decentralized structure specifically responsible for weather data collection. Weather data recorders located at sub-counties are centrally managed by UNMA. This is a major structural gap and it is evident that UNMA may need to have fulltime or seconded personnel at the district level to ensure that the weather stations are functioning properly and weather data collectors are doing their job.

In the institutional framework for the CHAI project, the sub-county level is one of the most important nodes. Market prices and daily weather data are collected at the sub-county-level through community development officers and weather recorders respectively. The extension agents who directly interface with farmers are also located at sub-counties. The processes of data collection and providing support to farmers based on the climate and agricultural information disseminated by CHAI are part of the routine tasks of the sub-county-based district local government staff.

Key Conclusions from Institutional Sustainability Assessment

The institutional arrangement tested by the project to support the generation and dissemination of climate and agricultural information has been streamlined to the business process at the national and district levels. At the national level, UNMA and the CCD are they organizations driving the CHAI approach. UNMA has integrated the use of mobile phones for collecting weather information from sub-counties and using such data for the generation of sub-county-specific forecasts and agricultural advisories. The Climate Change Department has established a knowledge management portal and information resources from the CCD's eLibrary are disseminated through CHAI. The project activities are also integrated with the activities of NAADS. The project is fully integrated with the business processes of the district local government of which the most pertinent are the Production, Natural Resources, Commerce and Community Based Services Departments. The districts have started budgeting for CHAI activities as part of their district-wide development plans. The integration of the project with NARO has been minimal. NARO develops, tests and approves the use of agricultural technologies for use by farmers, however, it doesn't have the infrastructure for disseminating such technologies. The dissemination of agricultural technologies to farmers is within the purview of the CHAI project and the linkage with NARO must be strengthened.

5.7.3 Technical Sustainability

The technical sustainability dimension assessed the interoperability of the CHAI system with existing systems used by pertinent government institutions especially UNMA, the reliable correct functioning of the technology developed/used by the project for supporting the generation and dissemination of climate information, and the availability of technical expertise at pertinent government institutions to support the day to day operations of the system.

The technical sustainability assessment included assessing whether the development of the climate and agricultural information system by the project meets user needs and is scalable.

Interoperability of the CHAI System

Defined as "the ability of two or more systems or elements to exchange information and to use the information that has been exchanged" (Radatz et al., 1990; Breitfelder and Messina, 2000), interoperability is an important feature for the CHAI project to ensure that there is seamless data exchange between CHAI and other applications used by partner organizations. The project used Open Data Kit (ODK) for collecting and storing market and weather data. ODK tools build on existing open standards and is supported by an open-source community. ODK's open standards ensure compatibility with other platforms used by UNMA and other players. Market and weather data collected using ODK forms developed by the project are stored in MySQL server installed at UNMA by the project. MySQL is an open-source relational database extensively used throughout the world; it is highly interoperable with other platforms. For the dissemination of SMS, the project used Uganda-based aggregators to ensure that the service is locally managed and supported.

Meeting User Needs

To gauge whether the climate and agricultural information disseminated by the project meets user needs, the households in the intervention districts were asked if the information received was relevant and effective in minimizing crop losses. Information relevance measured the extent to which the information met the needs of the users; and effectiveness measured the extent to which the information supported positive outcomes especially in the form of minimizing crop loss because of applying received information into action by the users.

As shown in the following table, over 88% of the households found the climate and agricultural information received through CHAI *very relevant to moderately relevant* for their farming needs, and over 83% found it *very effective to moderately effective* in minimizing crop losses.

Relevance / Effectiveness of Information	Soroti	Nakasongola	Sembabule	Total	
Relevance of Information	%	%	%	%	
Not relevant	5.7	14.8	15.0	11.8	
Moderate relevant	20.7	25.9	22.0	22.9	**Very to moderately relevant: 88%**
Relevant	50.7	40.7	48.8	46.7	
Very relevant	22.9	18.5	14.2	18.5	
Effectiveness of Information					
Not effective	7.1	24.7	18.9	16.9	
Moderate effective	38.6	27.2	23.6	29.8	**Very to moderately effective: 83%**
Effective	48.6	37.0	43.3	43.0	
Very effective	5.7	11.1	14.2	10.3	

Table 53: Relevance and effectiveness of climate and agricultural information

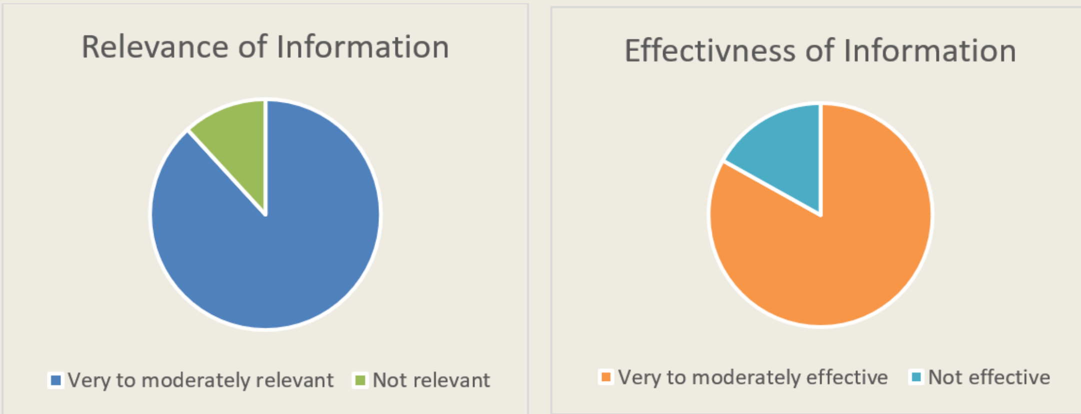

Figure 26: Relevance and effectiveness of climate and agricultural information

A farmer in Soroti, Hellen Mary Akiror grows millet, groundnuts, sorghum, cassava, and potatoes on her four acres land. Dependent on rain-fed agriculture for her livelihood, she noted that the information she receives through CHAI meets her needs and is effective in minimizing crop losses. She notes that crop yield from her land "*depends on planting the right crops at the right time. If I fail to plant the correct type of seed for a given season, I may lose all my harvest. The information I receive from CHAI helps me to decide which type of crop to plant and when. I have been using CHAI since 2013 and I had little crop loss because I fully applied the information I received into action.*"

The project uses an adaptive approach in the development and delivery of climate and agricultural information to farmers. The project encourages farmers to submit their feedback on the efficacy of the information they receive and the communication channel through which information was delivered. Content and delivery mechanisms are adjusted based on preferences of farmers and feedback. For example, farmers usually request specific topics be discussed on interactive radio talk shows on; depending on the popularity of the request, radio talk shows are organized to address farmers' questions.

A farmer in Nakasongola, Brian Mwagale, said *"we are very happy by the way the CHAI project delivers information to us. The information we receive is very relevant for our farming. The different channels through which we receive information are also very useful. We usually prefer radio broadcasts, but we cannot save the information from radio for future use. The information we receive through our phones can be saved and we can use it at later time as a reference. The communication channels are very balanced*".

Overall, the climate and agricultural information generated and disseminated by the project and its partners meets the needs of the users and is effective in minimizing crop losses.

Scalability of the System

The design of the CHAI climate and agricultural information system was modular to allow for scalability. The server application was designed with a web-based dashboard interface to allow for data export, report generation and visualization, facilitation of real-time data transfer from remotely located mobile devices, and deployment of new or updated data collection forms to mobile devices in the field. This means that several mobile phones can transmit data from remote sites to the server by simply using an Application Program Interface (API). The application at the server also allows data observers at the server to download and generate more accurate forecasts localized to sub-county level. UNMA generated seasonal reports for three-month and ten–day periods that forecast the onset, cessation, and intensity of rainfall for the sub-counties of the three intervention districts.

Key Conclusions from Technical Sustainability Assessment

The assessment showed that the tools developed by the project are interoperable with software applications used by UNMA and other organizations allowing easy exchange of information. CHAI's design was informed by the needs and priorities of farmer and the challenges faced by partnering organizations especially UNMA. Its approach meets user needs and its modular structure will allow scaling to a nationwide rollout and support customization to accommodate the generation and dissemination of emerging adaptation information needs.

5.7.4 Social sustainability

This section presents findings of the study about social sustainability of the CHAI Model. It shows how social and cultural preferences and practices in communities of intervention might promote or hinder the continuity and use of CHAI climate and agricultural information services. Specifically, the following aspects of social sustainability were assessed: socio-cultural preferences and practices and social networks to support the sharing and sue of information.

Socio-cultural Preferences and Practices

To assess aspects of social sustainability of the CHAI Model in the communities of intervention, study participants were asked to identify and mention any social or cultural practices existing in their respective communities that in one way or another might facilitate or impede the continuous use of climate and agricultural information. Results from field discussions revealed that there are no social or cultural barriers that limit the use of information from CHAI. Focus group discussions with farmers show that climate and agricultural information from CHAI are broadcast through local FM radio stations in their languages. Farmers invariably noted that the FM radio stations, the talk show hosts, and the participants in the talk show are highly respected by the community and the content that is broadcast is very respectful of the opinions of farmers.

Focus group discussants in Nakasongola noted that FM "*radio broadcasts for disseminating climate and agricultural information from CHAI are in our local language. We can ask questions in confidence. Our families and neighbors hear us asking questions and we hear them when they ask. The moderators and talk show participants respect our questions and answer it very politely. This makes us very happy and we always yearn for the next talk show to come.*"

Another focus group in Soroti district noted the importance of clan and community leaders' participation in the radio talk shows. They said: "*we have our clans and community leaders. The project invites them to participate in the talk shows. Their participation makes us to even embrace the CHAI more. When our clan leaders return from the talk show, we held meetings in our trading centers and they serve as the resource person for planning our farming activities. This program is ours, it is our voice*".

A female focus group in Sembabule concurs with the views of the focus groups in Nakasongola and Soroti. They noted that "*their female member of parliament usually participates in radio talk shows. She is a role model for many women farmers and they happily tune to CHAI programs in the local radio station*".

There are no socio-cultural barriers on the use of climate and agricultural information disseminated through SMS. However, some of the farmers have little trust in information received through text messaging on mobile phones. Their mistrust is because of the spam messages that they receive from some dubious companies and individuals who send bulk SMS messages promoting products and/or offering an "easy to win" lottery. Most of the lottery offerings are scam messaging. When the recipients respond to the message, they are automatically charged a SMS transmission fee without any warning. The unexpected expense becomes a major disappointment to the user. Such experiences have made some farmers suspicious of unsolicited text messages received on their phones. Some of the farmers choose to ignore messages on the mobile device to avoid unexpected financial loss.

Key informants and focus group discussants from the villages clearly noted that they were willing to use information received through mobile phones, however, they wanted to know if the information is legitimate or not. To help farmers recognize that messages are from CHAI, the numbers from which CHAI messages are sent are save on their phones and the name "CHAI" pops up when new text messages are received.

Social Networks to Support Dissemination and Use of Information

Cognizant of the fact that social sustainability largely depends on the strong sense of cooperation among beneficiaries of the project, this study assessed the availability of social networks that support the dissemination and use of climate and agricultural information. Participants were asked to indicate if formal and informal networks and other social groups where farmers come together existed in their communities and if these networks are used to promote the exchange and use of climate and agricultural information. Results show that there are various formal and informal networks in the communities and farmers regularly meet as part of such groups to discuss climate and agricultural information and other development issues affecting the community. These social groups bring together many people with shared beliefs, ideas, and attitudes, and therefore, they are an important source of information in the community. There was a consensus among participants that social networks can used to sustain the continued use of climate and agricultural information.

Focus group discussants in Nakasongola district noted that "*social groups are the most appropriate because these people trust each other and can easily share information among group members. It is also effective because instead of moving from house to house to share the information, the messages are shared in groups and all members are in position to get the information and share their perspectives*". Another discussant in Soroti district says, "*These groups are very good in passing on information because they meet rather regularly to discuss pertinent issues, because the extension worker cannot cover all of us, cannot move from home to home, but can meet us in our community groups where we can receive and share information*".

Farmers groups ranged from 25 to 500 members as shown in the following table.

Name of the group	**Average membership**
Soroti district- Arapai Sub-county	
Arapai Women Entrepreneurs Association	30
Kick off Poverty Development Organization	30
Alot Mothers Union	30
Dakabela Rural Women Association	25
Arapai Multipurpose Cooperative Society	500
Nakasongola-Wabinyonyi Sub-county	
Wabinyonyi Horticulture Farmer's Group	300
Wantabya East Development Farmers' group	40
Kewerimende Women Farmers' group	50
Akamu- Kamu Women Farmers' group	70
Kayakadoko Women Farmers' group	20
Kaderi Agaali Wamu Farmers' group	25
Wesige Mukama Kamunina Farmers' group	36

Kasagaka Farmers' Development Group	40
Mitanzi Women Develpoemt group	25
Kabayo Twizimbe Youth Farmers' group	45
Naitondo Farmers' group	35
Kabala Yesu Afayo	55
Sasila Muslim Women's group	35
Kakondi Agaali Wamu	25
Rwenyama Twimukye Youth Group	20
Kabongo Dojjo twekole	15
Kamalizila Women Farmers' group	25
Wabigalo Tusubila	45
Wabigalo Wesige Mukama	25
Kamalizila Yesu Afaayo	90

Table 54: Examples of farmers groups in Soroti and Nakasongola districts

From field studies conducted by the project, it is evident that community social networks promote a sense of belonging among individuals, are a vital source of community information, and are an important channel for the sustainable use of climate and agricultural information disseminated by the project.

Key Conclusions from Social Sustainability Assessment

The assessment showed that climate and agricultural information provided by the project is easy to access and use by farmers; is in accordance with social and cultural preferences and practices; and is considered by users to be worth the time and cost incurred to obtain the information.

6. Project Outputs

The major project outputs of the project include the following:

- Two surveys involving 640 households (wave-1) and 813 households (wave-2) in three intervention districts and one control conducted; qualitative study involving focus group discussions and in-depth interviews conducted.

- Analysis of quantitative and qualitative data from two surveys (wave-1 and wave-2) completed.

- Climate and agricultural information disseminated to over 250,000 farmers including seasonal and 10-day forecasts specific to sub-counties, agricultural advisories to help farmers plan their crop/livestock farming in response to forecasted climate/weather conditions, weekly market information reports, low-cost water harvesting techniques, and termite control measures identified, packaged, and disseminated to communities via interactive FM radio broadcasts (talk shows and spot messages), SMS broadcasts, community loudspeakers, and face-to-face meetings.

- Completed sustainability assessment of the CHAI model focusing on financial, institutional, technical, and social dimensions of sustainability.

- Developed a total cost of ownership model that provides the financial requirements for expanding the CHAI model providing the per-district and per-household costs for expanding and maintaining the system.

- A total of 35 smartphones procured from local vendors in Kampala; installed with weather and market data collection and transmission system and provided to sub-county-based community development officers and weather recorders for market prices and weather data collection and submission to a central database.

- A total of 75 rainfall observers and agricultural extension agents trained on the use of mobile phones for gathering and transmitting weather and market data.

- District officers and farmers group leaders from the intervention districts received two-day training on the application of weather and climate information to agriculture. The training was provided by the project team and agro-meteorologists from UNMA. A total of 52 district officers and farmers were trained.

- Conducted three stakeholders' meetings involving senior government officials (Minister of Water and Environment, directors and commissioners), researchers from Makerere University and other research institutions, NGOs, district local government officials, and farmers. The stakeholders' meetings were designed for obtaining inputs from the participants for developing the research and implementation approach and facilitating the use of findings of the project.

- Conducted face-to-face meetings with high level policy makers from the Ministry of Water and Environment on the project's research findings and how the findings can be utilized for informing national policy; and with parliamentary committee on climate change.

7. Project Outcomes and Impacts

7.1 Outcomes

The study showed that water stress, floods, plant diseases, and hailstorms were the major challenges farmers faced during the growing seasons in 2015/16 and 2016/17. The project has disseminated climate and agricultural information to over 250,000 farmers to help them minimize the impacts of the climatic stressors. To study if the adaptive capacity of the households in the intervention districts has improved, the project compared intervention districts and the control district of Rakai using the following indicators:

- Access to climate and agricultural information;
- Relevance and effectiveness of received information for minimizing risks; and
- Minimization of crop loss because of application of information provided by the project into action.

Improved access to climate and agricultural information: There was a marked difference in access to climate and agricultural information between the intervention districts and the control district of Rakai. A significant proportion of the respondents in the intervention districts had better access compared to the control district. The study showed a significant variation in the proportion of respondents with access to climate and agricultural information by district ($p<0.05$). Soroti had the highest proportion of respondents with access to climate and agricultural information (77%) followed by Sembabule (56%), Nakasongola (45%), and the control district of Rakai with only 9% of the respondents having access to such information.

On average, 59% of the households in the intervention districts had access to climate and agricultural information compared to 9% in the control district. Overall, about 6 in 10 households in the intervention districts received information from the project while only 1 in 10 households in the control district received information from other sources.

Improved relevance and effectiveness of agricultural information: To gauge whether the climate and agricultural information disseminated by the project met user needs, the households in the intervention districts were asked if the information was relevant and effective in minimizing crop losses. Information relevance measured the extent to which the information met the needs of the users; effectiveness measured the extent to which the information supported positive outcomes especially in the form of minimizing crop loss through application of the received information by the users.

Over 88% of households found the climate and agricultural information received through CHAI *very relevant to moderately relevant* for their farming needs, and over 83% found it *very effective to moderately effective* in minimizing crop losses.

7.2 Impacts

Improved household income: The study showed that the intervention districts sustained less crop loss in terms of acres compared to the control district of Rakai. Crop loss and damage in terms of acres in Rakai was almost twice as high as the loss in Nakasongola (5.8 in Rakai, 5.1acres in Sembabule, 3.7 acres in Soroti district, and 3 acres in Nakasongola district). Results from the first wave of the study conducted in September 2016 show that the control district of Rakai sustained the highest crop loss and damage ($520/year/household) followed by Sembabule ($464/year/household), Soroti $303/year/household), and Nakasongola ($209/year/household). Households in the control district of Rakai sustained about 11% more crop loss than did households in Sembabule, 42% more than households in Soroti, and 60% more than households in Nakasongola. During the first wave of the study (Sept 2016), the average monetary value of crop loss for the intervention districts was $325/year/household while households in Rakai lost crop with average value of $520/year/household showing that the control district of Rakai sustained 37% more than the intervention districts in crop loss. ***The study showed that households in the intervention district's income was higher than the households in the control district by $195/year/household.*** During the second wave of the study (2017), the intervention districts were severely affected by fall armyworm compared to the control district of Rakai during the second wave of the study resulting in more crop losses. In 2017, the benefits gained using the climate and agricultural information by households in the intervention districts were wiped out by armyworm infestations that destroyed crops in the districts. The control district of Rakai was not affected by fall armyworm in 2017 making comparisons of crop loss and damage between the control and intervention districts impossible.

Strengthened Institutional capacity: The sustainability and long-term success of a development program requires local ownership and the strengthening of local capacity and local systems to produce the required outcomes at national and local levels. The availability of well-maintained and dense observational networks for weather and climate is of critical importance for seasonal forecasting and other weather-dependent sectoral applications especially for the agriculture sector. However, UNMA capacity to capture and use timely weather data was constrained by the lack of adequately dense observational networks and delays in the submission of weather data. The project working with UNMA installed 22 rain gauges at subcounty level at the intervention districts and introduced the use of mobile phones for capturing and submitting weather data daily. UNMA is currently using a server installed by the project for receiving weather data from sub counties which is enabling the agency to generate subcounty-specific seasonal forecasts and agricultural advisories. Based on lessons learned from the project where UNMA played a key role, UNMA has hired 50 weather data recorders who are submitting daily weather data from districts other than the project's intervention districts.

8. Recommendations

The CHAI project, started in January 2012 with funding from the International Development Research Centre, Canada (IDRC), was a collaboration among Uganda Chartered HealthNet (UCH), FHI 360, Uganda Ministry of Water and Environment/MWE (Climate Change Department/MWE, National Meteorological Authority and Wetlands Management Department), Makarere University (College of Agricultural and Environmental Sciences and Department of Zoology). The first phase of CHAI (CHAI-I) was implemented January 2012 – December 2014; the second phase of the project, covered in this report, was implemented October 2015 – January 2018.

The two phases of the CHAI project had distinct objectives. The first phase of the project proved that using traditional technologies such as radio broadcasts in combination with mobile technology for the generation and dissemination of agricultural advisories and climate change adaptation information enhances the adaptive capacity of small-holder farmers affected by the vagaries of climate change. Adaptation information reached about 100,000 farmers in the local languages; 75% of the households reported applying the received information. CHAI-I showed that the innovative approach developed by the project for the generation, dissemination, and enhanced application of climate information reduces crop loss and damage and increases crop yield and household income. A study involving 640 households, focus group discussions, and in-depth interviews showed that a significant proportion of the respondents in the intervention districts reported better access to climate-related adaption information compared to the control district of Rakai (Soroti 74%, Sembabule 46%, Nakasongola 38%, and Rakai 27%). Usefulness of adaptation information in the intervention districts ranged from 63% to 93% while only 47% of the respondents from Rakai found it useful. Effectiveness of adaptation action ranged from 72% to 93% in the intervention districts and 66% in the control district. The study showed that the timely delivery of localized climate information through the project reduced crop loss and damage by 40% to 65%.

In Phase 2, CHAI more than doubled its reach to over 250,000 farmers by employing interactive FM radio broadcasts, text messaging, email, and face-to-face meetings. The project provided farmers with climate and agricultural information including seasonal weather forecasts and agricultural information localized to the sub-county level; weekly livestock and crop market information to help them decide what, when, where, and how much to sell; and guidance on low-cost rainwater harvesting techniques, drought and flood coping mechanisms, and termite control measures.

The study conducted by the project showed that the CHAI solution meets user needs, is in concordance with the existing ecosystem, is modular in design allowing its expansion to scale, and its maintenance and improvements can be supported by government and local private institutions. The study showed that 35% of the farmers are willing to pay an average of about US $4/year/household for climate and agricultural information.

Effective adaptation information generation, dissemination, and utilization require a combination of innovative technological and institutional arrangements. The project has established an elaborate institutional arrangement to support the generation, dissemination, and use of climate and agricultural information. Through CHAI-2, the generation of adaptation information has been mainstreamed into the business processes of pertinent institutions such as the Uganda National Meteorological Authority (UNMA); Climate Change Department (CCD); and district-based farmer support agencies such as the Production, Natural Resources Management, Community Development, Commerce, and Communications Departments. The study conducted by CHAI-2 shows that the institutional adaptation framework developed by the project is fully consistent with the Uganda National Climate Change Policy (UNCCP), which was adopted and approved by the Ugandan Cabinet in January 2014.

To support the sustainability and long-term success of the ICT-based climate and agricultural information system and assist smallholder farmers to minimize crop losses due to climate-related hazards, the following are recommended.

Expand observational networks of UNMA: The availability of well-maintained and dense observational networks for weather and climate is of critical importance for seasonal forecasting and other weather-dependent sectoral applications especially for the agriculture sector. UNMA assessments show that, currently, out of 20 agrometeorological zones in Uganda, only 8 have observation stations; out of 20 hydro-meteorological zones, only 6 have observation stations; out of 16 synoptic zones, only 12 have observation stations; out of 600 rainfall zones, only 150 have stations. As a temporary measure, the project, working with UNMA, installed 22 rain gauges at the subcounty level in the intervention districts. However, to generate reliable seasonal and 10-day weather forecasts and agricultural advisories localized to the subcounty-level, UNMA needs to make significant investments to expand its observational network coverage. The ideal solution is the installation of automatic weather stations (AWS), however, initial costs associated with purchase, installation, and maintenance are lower for manual instrumentation. UNMA has identified priority areas for AWS. In areas where manual instrumentation is installed, it is recommended that UNMA use the mobile application developed by the project for capturing daily weather data and submitting it to the server installed by the project at UNMA in Kampala. Both automatic and manual weather stations will require an attendant. UNMA needs to hire and train subcounty-based weather records/attendants who will be responsible for recording data and maintaining weather stations.

Strengthen UNMA human resources: The generation of location-specific climate and agricultural information requires a dedicated team of weather forecasters and agro-meteorologists. The number of forecasters and agrometeorology during the study was only 4, which is far below the required number. It is recommended that the number of forecasting and agrometeorology team be increased to 12 – 14 to enable them to generate subcounty specific seasonal forecasts and agricultural advisories. Uganda is delineated into 16 climatological zones based on principal component analysis with each of the zones having their own characteristics and it is recommended that forecasters be assigned to a specific zone(s) to enable them to build unique capabilities related to the zones and improve the accuracy of forecasts through iterative model selection.

Strengthen district-level climate governance: The Uganda National Climate Change Policy and Uganda five-year National Development Plan (2015/16–2019/20) emphasize the need to institute an organizational structure to address climate change issues at national and local levels. At the national level, the coordinating body is the Policy Committee on Environment. It is chaired by the prime minister; the Ministry of Water and Environment through the CCD serves as the secretariat. This body is advised by the National Climate Change Advisory Committee which is chaired by the Ministry of Water and Environment with the CCD serving as the secretariat. Each ministry is expected to have climate change focal person or desk with coordination at the national level by the Ministry of Planning and Ministry of Finance. At district local government level, climate change activities are coordinated by the District Environment Committee chaired by the Chief Administrative Officer with the district Natural Resources and Environment officer serving as secretariat. All district-level technical departments are members of the Environment Committee. The district Environment Committees played a crucial role in streamlining the localization and delivery of climate and agricultural information in the district. However, the operationalization of the district Environment Committee is not consistently implemented throughout the country. It is recommended that the CCD provide ongoing support to district local governments to establish and operationalize the district Environment Committee.

Strengthen CCD's eLibrary with localized climate change content: The CCD has an eLibrary to serve as a knowledge base for supporting climate change mitigation and adaptation actions in Uganda. The project has been using the CCD's eLibrary as the source of climate information for dissemination to small holder farmers in the intervention districts. However, the eLibrary has few resources that are locally developed and a limited amount of content that can be used by less-educated rural smallholder farmers. The few locally developed resources in the eLibrary are "expert-driven" that are entirely developed by subject matter experts in climate change and agriculture. Most of the content in the eLibrary needs to go through a localization process to ensure that content is tailored to fit the local context, adapted into local languages, and produced in a way that engages smallholder farmers. Addressing the lack of locally relevant climate and agricultural content is critical to ensuring that the transformative potential of this approach is fully maximized by smallholder farmers. Towards this end, *it is recommended* *that the CCD introduce a content curation approach for selecting, organizing, localizing, and presenting climate information that is meaningful to smallholder farmers*.

Engage private sector to co-finance expansion: The annual total cost of ownership (TCO) for national expansion of the climate and agricultural information system is $11,721,638/year. The TCO analysis conducted by the project showed that over 88% of the budgetary requirement supports the dissemination of information via SMS. The analysis shows that a 10% reduction in the cost of sending/receiving SMS messages reduces the total cost of ownership by close to 9%. For example, if the bulk SMS provider reduces the current per outgoing SMS message rate of 35 UGX (US $0.01) by 10% (making the rate per outgoing SMS message 31.5 UGX), the annual total cost of ownership will reduce from $11,721,638/year to about $10,690,134/year. In other words, each 10% reduction in the per outgoing SMS rate will result in the reduction of over $1 million in the annual total cost of ownership of the system. Public-Private Partnerships that entail agreements between the government and mobile network operators for financing the dissemination of climate and agricultural information is an important financing option. It is recommended that the Ministry of Water and Environment negotiate with mobile network providers to reduce the rates associated with the delivery of information via SMS. The mobile network operators indicated their interest to negotiate favorable rates with pertinent bodies of the government.

Increase the role of agricultural research organizations: The National Agricultural Research Organization is the mandated body for guidance and coordination of all agricultural research activities in the national agricultural research system in Uganda. NARO provides support for the generation of yield-enhancing technologies as stipulated in the National Agricultural Research Act 2005. Promoting the delivery of high quality, efficient agricultural research services through the provision of guidelines and guidance, NARO coordinates and promotes cooperation and collaboration between Uganda and other countries, institutions, scientific or professional societies, and other agricultural research service providers, about agricultural research, development, and technology transfer in the agricultural sector to optimally utilize agricultural resources and improve production capacity of such resources. NARO's role is limited to agricultural technology development and not dissemination; CHAI's role is to disseminate technologies that are suitable for current climatic conditions. As such, NARO and CHAI are natural allies and their integration serves the purposes of both initiatives. However, the linkage between NARO the CHAI initiative was weak. A key recommendation is to actively engage NARO to facilitate the dissemination of proven agricultural technologies to farmers through the CHAI platform.

Conduct ongoing research: While the CHAI model has garnered credibility in the eyes of the farmers using the solution and with government bodies, and the institutional arrangement required for implementing the CHAI model has been tested, the mechanisms for scaling up the solution in Uganda and other Sub-Saharan countries are yet to be determined. A key recommendation to address this gap is to study how an ICT-mediated climate and agricultural information delivery service like the CHAI model can be expanded most effectively as a responsive and adaptive system for bringing impact at scale. In conducting the proposed study, the role of field demonstrations of weather forecast-based farming for farmer adaptation and uptake using participatory approaches should be assessed.

9. Annex I: List of Organizations that served as an "Action Resource"

Nakasongola District

No.	Name of organization that served as an "Action Resource"	Role played by "Action Resource"
1.	Operation Wealth Creation	Provision of coffee tree seedlings and maize and beans seeds.
2.	District Production and Agricultural Departments	Provision of fruit trees such as orange and mango tree seedlings; making extension agents available for face to face meetings with farmers at village levels; localization of information to make it suitable to sub-counties and villages in the district.
3.	District Natural Resources Department	Advising farmers on sustainable agricultural practices and protecting the environment.
4.	District Environment and Forestry Department	Advise and support on the use of tree plantation as an auxiliary income source for farmers to diversify their income source and minimize risks.
5.	International Center for Research and Agroforestry (ICRAF)	Provision of fruit trees such as avocado, tangerines, and guavas
6.	Commercial Department	Provision of training to famers on book keeping
7.	Global Climate Change Alliance (GCCA)	Provision of inputs and advisory on agroforestry and fruit tree nurseries
8.	Global Climate Change Alliance	Training farmers on building their entrepreneurial skills in stove construction and providing necessary inputs
9.	Global Climate Change Alliance	Providing inputs and training on the construction of water reservoirs or small dams
10.	Nakasongola District Farmers Association (NADIFA)	Providing inputs and training of farmers on water dam maintenance and vegetable gardens
11.	World vision	Training of farmers on crop value addition, bookkeeping and construction of water harvesting tanks and water wells

12.	Save the children	Provision of environmental education and agricultural inputs
13.	Buruli Kingdom	Providing climate and agricultural information received from CHAI to farmers to expand reach and scale
14.	Religious Leaders	Providing climate and agricultural information received from CHAI to farmers to expand reach and scale

Sembabule District

No.	Name of organization that served as an "Action Resource"	Role played by "Action Resource"
1	Operation Wealth Creation	Provision of coffee tree seedlings and maize and beans seeds.
2	District Production Office	Provision of fruit trees such as orange and mango tree seedlings; making extension agents available for face to face meetings with farmers at village levels; localization of information to make it suitable to sub-counties and villages in the district.
3	Natural Resources department	Advising farmers on sustainable agricultural practices and protecting the environment.
4	Environmental and Forestry departments	Advise and support on the use of tree plantation as an auxiliary income source for farmers to diversify their income source and minimize risks.
5	Global Climate Change Alliance	Provision of inputs and advisory on agroforestry and fruit tree nurseries
6	Global Climate Change Alliance	Training farmers on building their entrepreneurial skills in stove construction and providing necessary inputs
7	SEDIFA District Farmers Association	Providing inputs and training of farmers on water dam maintenance and vegetable gardens
8	World vision	Training of farmers on crop value addition, bookkeeping and construction of water harvesting tanks and water wells
11	Farmers' media	Providing climate and agricultural information received from CHAI to farmers to expand reach and scale

Soroti District

No.	Name of organization that served as an "Action Resource"	Role played by "Action Resource"
1	Operation Wealth Creation	Provision of coffee tree seedlings and maize and beans seeds.
2	District Agricultural Office Department	Provision of fruit trees such as orange and mango tree seedlings; making extension agents available for face to face meetings with farmers at village levels; localization of information to make it suitable to sub-counties and villages in the district.
3	Natural Resources department	Advising farmers on sustainable agricultural practices and protecting the environment.
4	World vision	Training of farmers on crop value addition, bookkeeping and construction of water harvesting tanks and water wells
6	Save the children	Provision of environmental education and agricultural inputs
7	Soroti Catholic Diocese Integrated Development Organization (SOCADIDO)	Provision of agricultural inputs such as tree seedlings and maize, beans, groundnuts seeds
8	Disaster Risk Reduction Platform (DRRP4T)	Provision of emergency food and non-food items to disaster victims
9	Arapai Farmers' Cooperative society (AFAMCOS)	Facilitate the sale of crop at wholesale and retail levels

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