Using Information and Communication Technologies (ICTs) for Water Adaptation in Uganda

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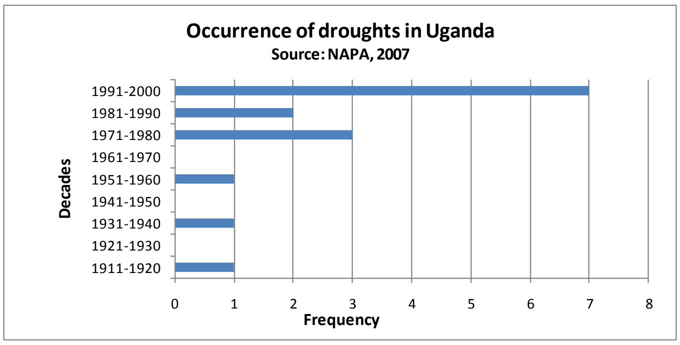
ABSTRACT

Climate change presents significant risks to the livelihood and well-being of the Ugandan population. The “cattle corridor”, representing about 40% of the country’s land, is one of the areas most affected by the impacts of climate change. The Climate Change Adaptation and ICT (CHAI) project was designed to assess whether the ability of “cattle corridor” communities, to plan for and respond to climate-induced water challenges, could be enhanced. The project conducted a study to assess climate-related hazards and their impacts and to gauge the adaptation information and communication needs of the communities. Results were used to inform the design of a community-based climate management information system and to tailor locally-driven adaptation messages relevant to the lives of the people. Preliminary feedback from communities showed they made better selections of crop seeds suited to the season and decided when, what, and where to sell their agricultural products to improve livelihood.

INTRODUCTION

Climate change presents a significant threat to the well-being of the Ugandan population. Studies show that climate change and variability are threatening Uganda’s ecosystems and the livelihoods of the population that depends on them (Hepworth 2008). The Uganda National Adaptation Programme of Action (NAPA) established that climate change and variability are manifested in escalating droughts and floods and seasonal variations, especially changes in the onset and cessation of rains (Uganda NAPA 2007). Analysis of historical rainfall data from 1911 to 2000 shows an increasing trend in the occurrence of droughts. During the 80 year period from 1911 to 1990, eight droughts occurred, while in the ten years between 1991 and 2000 Uganda experienced seven droughts. Higher average temperatures and more frequent and severe climatic incidents in Uganda result in diminishing food security, decreasing quantity and quality of water, and deteriorating natural resources, negatively affecting health, settlements, and infrastructure (UNDP-UNEP 2009).



According to the Water Poverty Index (WPI), which encapsulates five primary measures including existing water resources, access to and capacity to employ the resources, use of water for domestic and agricultural purposes, and environmental impacts, Uganda ranks among the lowest 20 water-poor countries out of the 147 nations included in the study (Lawrence 2003). Rapid population growth, increased industrialization, unchecked environmental degradation, and pollution are increasing pressure on freshwater resources, especially in the most ecologically vulnerable areas of the country such as the “cattle-corridor” and the lowlands ecosystem (MWE 2007). Situated in a semi-arid ecosystem and covering 40% of Uganda’s land area, the cattle-corridor is characterized by scanty and unreliable rainfall (450 – 800/year), recurrent droughts, and sparse vegetation. Considered one of the most fragile areas in Uganda (Lufafa 2006) and particularly vulnerable to climate changes (Uganda NAPA 2007), the cattle corridor experiences higher proportions of water stress than other parts of the country.

The literature suggests that Information and Communication Technologies (ICTs) can play an important role in monitoring, mitigating, and adapting to climate change. The role of

ICTs in gathering and analyzing meteorological data and the use of communication systems in the prediction and response to natural disasters is well documented (ITU 2008). Early reports from projects utilizing ICT for climate change adaptation in the developing world indicate the potential of emerging technologies such as mobile phones and traditional technologies such as radio broadcasts to improve the gathering of data and the dissemination of information on adaptation options. (Heeks 2010). For example, rural communities in Vietnam were trained to use mobile phones to measure flood levels in their localities and transmit the data via Short Message Service (SMS) enabling local agencies to make better forecasts, prepare more precise flood warnings, inform communities to prepare for evacuations, and advise populations on how to protect themselves and their assets from flooding (MRC 2009). However, the use of ICTs for improving the adaptive capacity of communities is still in its infancy and there is much yet to be learned about the roles and potential of ICT for improving adaptation.

PROJECT GOAL AND DESCRIPTION

The Climate Change Adaptation and ICT (CHAI) project was designed to better understand the ways in which the ability of individuals and communities in the cattle corridor could be enhanced to plan for, and respond to, climate-related water challenges using ICT tools. The project aimed to achieve this by developing and deploying an effective information delivery mechanism which leverages the use of mobile and traditional technologies for ICT-mediated dissemination of seasonal forecasts, early warning messages, and adaptation options to rural communities in three intervention districts (Nakasongola, Sembabule, and Soroti) and one control district (Rakai) in the cattle-corridor. Funded by the Canadian International Development Research Centre (IDRC), the project was implemented by the Ministry of Water and Environment (Climate Change Unit - CCU, Meteorology Department, Wetlands Management and Directorate of Water Resources), FHI 360, Uganda Chartered HealthNet, and Makerere University (College of Agricultural and Environmental Sciences, College of Health Sciences, and Zoology Department). The CCU has incorporated the project into its portfolio and provided overall direction to the effort.

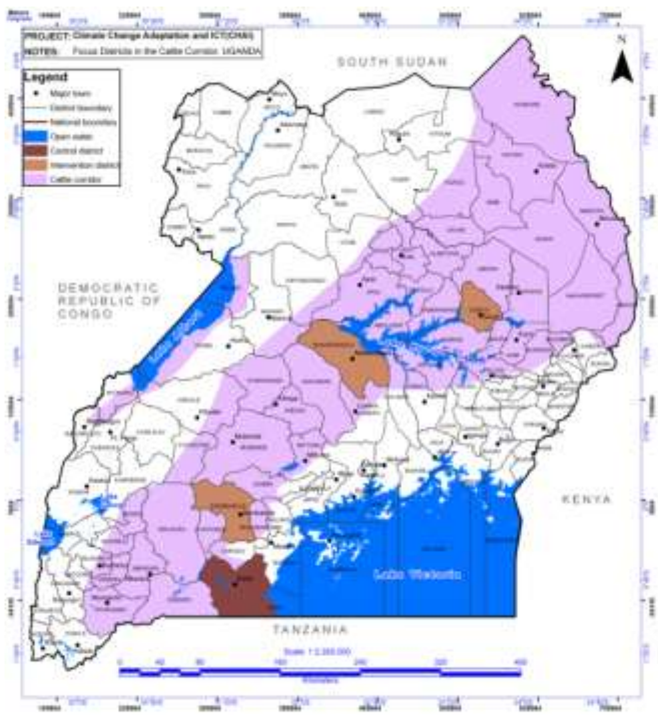


Figure 1 CHAI study area

The project commenced with a study to establish an understanding of the climate-related hazards in the pilot districts; exposure of communities and assets to these hazards; impacts of the hazards on people and their assets; adaptation information needs of communities to cope with the impacts of the hazards; trusted sources of information of the communities; and mechanisms and accuracy of adaptation information sharing at community and government levels. The project planned to use the findings to custom design and implement an innovative community-based climate information management system for delivering locally relevant, accurate climate change adaptation content to communities in rural Uganda using an institutional framework of farmer support institutions. The project is ongoing and impact assessment will be completed in 2014.

METHODS AND MATERIALS

Study Design

Conducted in the four pilot districts, the study employed a mixed methods approach combining quantitative and qualitative techniques, and analysis. A stratified random sampling design was used in selecting respondents for the quantitative aspect of the study. Sub-counties (third level of the administrative structure) in the study districts were classified into two strata: predominantly livestock-based and predominantly crop-based agriculture livelihoods. For each stratum in every district, a sub-county was randomly selected. The sample size of the study was 640 heads of households (**Table 1**).

Table 1 Sampling frame

District	Sub county (1/stratum)	Parish (2/sub county)	Villages (2/parish)	Households (20/village)
Soroti	2	4	8	160
Nakasongola	2	4	8	160
Sembabule	2	4	8	160
Rakai	2	4	8	160
Total	**8**	**16**	**32**	**640**

A structured questionnaire was designed to determine the hazards experienced in the area and to assess the exposure of the households and their assets to the hazards. The questionnaire was also used to collect data on individuals' current adaptive capacity[1], access to adaptation information, and ownership and use of information and communication technologies. The qualitative aspect of the study involved focus group discussions (FDG) and in-depth interviews with key informants to investigate perceptions and adaptive responses of farmers and institutions to the impacts of climate change and variability. Observations were gathered to better understand actual practices in natural settings. The household survey, FDGs, in-depth interviews, and onsite observations helped in triangulating the findings. Temperature and rainfall projections were generated using archival content based on global climate projections from the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project phase 5 (CMIP5) multi-model dataset. The study team applied two Representative Concentration Pathways (RCP4.5 and RCP 8.5) and applied 20 different General Circulation Models (GCM) for downscaling the projections on temperature and rainfall to the four pilot districts.

[1] Adaptive capacity refers to the potential or capability of individuals and communities in the cattle-corridor to adjust to the impacts of changing climate. The indicators used for assessing adaptive capacity include current water supply options for domestic and agricultural use and their diversity; access to water for domestic and agricultural use; livelihood and income diversity of communities; awareness of vulnerability to climate related impacts on water; access to and use of climate-related knowledge; and formal and informal networks and institutions supporting adaptation of individuals and communities in the project area to water stress and excess.

The functional capability of the community-based climate information management system that disseminated locally relevant climate change adaptation content using a mix of ICT tools for improving adaptive capacity has been informed by the findings of the qualitative and quantitative studies. The system has been deployed in Nakasongola, Sembabule and Soroti (intervention districts). Rakai district which possesses similar climatic conditions to the intervention districts, serves as the control site.

Data Collection

A structured questionnaire was developed, loaded onto mobile devices, and administered to a total of 640 household heads and household members from 32 villages. Focus group discussions and in-depth interviews with key informants were tape-recorded. The field data collection was conducted over a period of three weeks (August 6 – 27, 2012). Baseline data for developing the rainfall and temperature projections included historical daily observed rainfall and minimum and maximum temperature for the period 2000 – 2009 obtained from Uganda's Meteorology Department. Additional data was obtained from the Space Studies of National Aeronautics and Space Administration's (NASA) Modern Era-Retrospective Analysis for Research and Applications (MERRA).

Data Analysis

Data from the household survey was entered into SPSS version 21 software and analyzed using cross-tabulation and correlations. Percentages, frequencies, and chi-square values were obtained for descriptive statistics while inferential statistics performed on the collected data was used for generating trends. Qualitative data was analyzed using Atlas.ti to code transcripts according to themes; explore coded textual data for patterns and relationships; and establish cause-effect relationships. Precipitation and maximum and minimum temperature projections for mid- century and end of century were developed using

R, a free programming language and software environment for statistical computing and graphics display, and a climate projection script developed by Alex Ruane, a postdoctoral fellow at the Goddard Institute for NASA.

RESULTS

The results of the study show the major climate-related hazards and exposure of communities and their assets to the hazards; impacts of the hazards; current adaptation information needs of communities; and rainfall and temperature projections for mid-century and end-century. The findings were used to develop a community-based climate information management system for tailoring key messages to the communities. A final study to assess the efficacy of ICT-enabled adaptation information exchange in enhancing the adaptive capacity of individuals' and communities' to climate-related water stress/excess will be conducted in 2014.

Major hazards and exposure

The study showed **drought** is the major hazard to which the communities are exposed (**Figure 2**). Shifts in seasons characterized by changes in the onset and cessation of rainfall compared to the normal patterns, climate-related diseases, and heavy rainstorms associated with flooding were other prominent hazards. When asked to rank, in order of severity, the worst climatic hazards on their livelihoods, Nakasongola and Sembabule districts reported drought as the highest ranked with percentage of 67% and 60% respectively. **Climate-sensitive diseases** ranked second among the hazards with the highest percentages recorded in Rakai (44%) and Soroti (33%). Interestingly, climate-related diseases and flooding constituted the 1st and 2nd most severe hazards in Soroti district.

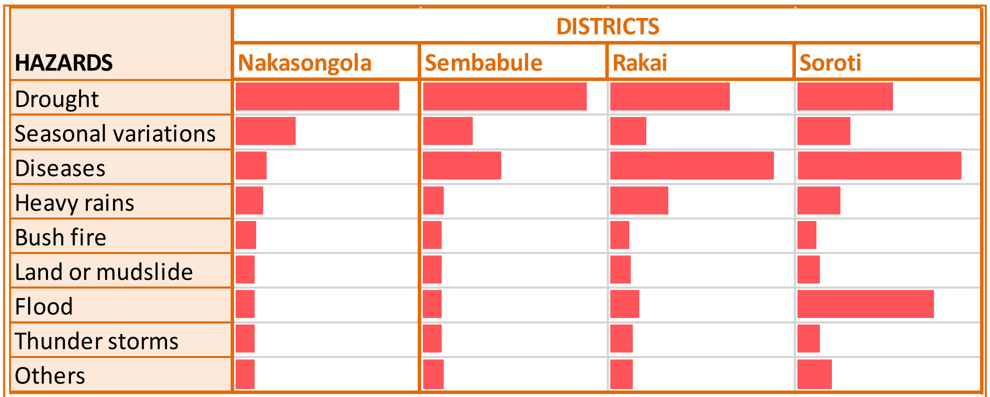


Figure 2 Major hazards with the worst impact on livelihoods

Rainfall and Temperature projections

The temperature and rainfall projections for mid-century and end-century show a rise in temperature in the pilot districts. The majority of models predict an increment in rainfall with varied magnitude of increase in all the pilot districts. The projected changes in minimum and maximum temperature (ΔTmax and ΔTmin) and rainfall in the studied districts for RCP 4.5 are provided in **Table 1**. A comparison of the downscaled model of results with observations and reanalysis data showed that all models simulate surface temperature and precipitation well across different models (correlation coefficient 0.55 to 0.64). The projected temperature and rainfall increase will likely result in the increased occurrence of extreme events such as droughts and floods concomitantly increasing the risk of pest infestations and proliferation of plant and animal diseases.

Districts	Mid-Century			End-Century		
	ΔTmax	ΔTmin	Rainfall - % increase	ΔTmax	ΔTmin	Rainfall - % increase
	°C			°C		
Rakai	1.46	1.74	8.76	2.15	1.84	13.13
Sembabule	1.44	1.74	6.94	2.80	2.17	11.93
Nakasongola	1.40	1.59	15.67	1.76	1.96	20.37
Soroti	1.41	1.63	17.25	1.76	2.04	23.14

Table 2: Projected change in Temperature and rainfall in the studied districts RCP 4.5

Impact of Hazards

Communities suffered from severe **water shortages** for domestic and agricultural use. The availability of water for livestock has diminished for 60% of the respondents in Sembabule, 43% in Nakasongola, 34% in Soroti, and 27% in Rakai districts compared to the 1980s and

1990s. Availability of water for human consumption and crop production followed a similar diminishing trend. The major sources of livelihood for the communities, crop farming (61%) and livestock (25%), were dependent on the availability of rainfall and were severely affected by shortage and variations in the availability of water. The study found **loss of crop** to be another major impact of droughts. In addition, heavy floods washing away crops and prolonging soil saturation in low-lying areas significantly affected crop growth in Soroti district.

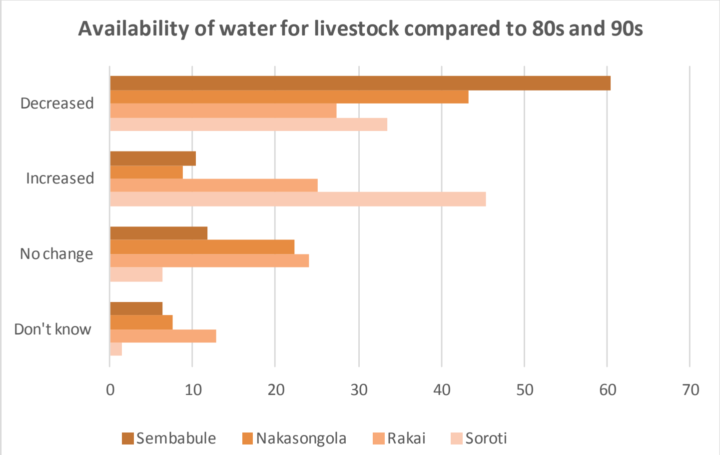


Figure 3 Availability of water for livestock compared to 80s and 90s

High mortality rate of livestock during droughts and long dry spells were experienced due to the lack of adequate drinking water, insufficient forage, and animal diseases. The study found that the scarcity of water and pasture forced farmers to engage in long distance **migration** with their livestock in search of water and forage. The migration routes the project mapped in Nakasongola and Sembabule districts show that pastoralists usually travelled 4 to 5 and 5 to 6 hours, respectively, to reach reliable water sources during dry seasons. As a result, **conflict** over access to water and pasture were very common in the study districts. During prolonged dry periods in Nakasongola district, **termites** attacked crops, pasture, and trees. Evidence from other research shows that vulnerability to termite attack increases where drought conditions exist (Cowie 1989). Assets such as roads and houses were destroyed due to flooding, hailstorm, thunderstorms, and termites. The most destructive hazard for physical asset damage was flooding, most prominent in Soroti district.

Adaptation Information and Communication Needs of Communities

Data analysis of the household survey, focus group discussions, and in-depth interviews with key informants showed that the major adaptation information needs of the households in the pilot districts were related to **coping and recovering from droughts** (60%) and **floods** (35%) (**Figure 2**).

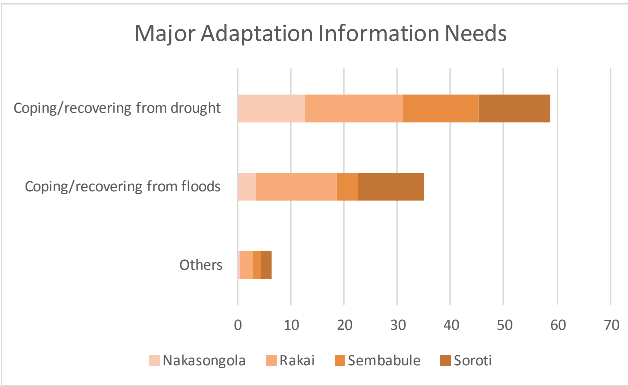


Figure 4 Adaptation information needs of communities

Communities expressed the need for more accurate, **localized seasonal forecasts** to support them in averting agricultural losses other than the current unreliable forecasts disseminated to them. The study showed that 51% of the respondents received seasonal weather forecasts primarily through the radio. However, only 47% of the respondents who received the forecasts used the information for influencing their decisions; the remaining 53% did not use the forecasts because they were unreliable and/or not localized for their area. In the face of variable weather patterns in the districts, they noted that **advisories about planting (eg. early maturing crops), harvesting, and livestock management** would help them make informed decisions and possibly avoid the loss of crops, livestock, and other assets.

Community members also expressed strong interest in receiving information about **low-cost water harvesting techniques** including design, cost, operation, and maintenance and suggested uses of the harvested water to help them cope with water stress.

The study showed that during droughts, one of the coping mechanisms of pastoralists was selling their livestock and using the cash to buy food. However, due to limited access to market information, they usually were forced to sell their livestock at very low prices. Local traders traveling to villages usually bought crop and livestock on their terms because the farmers did not know the market price in urban or semi-urban market outlets. About 85% of the respondents expressed strong interest in receiving **local market information** that provided retail and wholesale prices for livestock and other agricultural commodities (**Figure 3**).

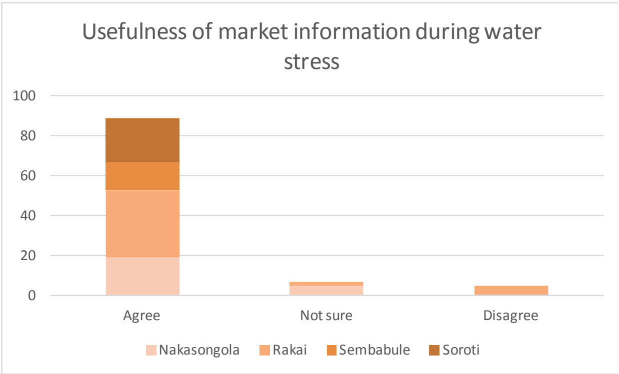


Figure 5 Usefulness of market information during water stress

Discussions with Communities' and local government officials showed that communities living in low-lying areas of Soroti district coping with flooding hazards would benefit from adaptation information on protecting water sources from contamination during flooding; minimizing the risk of water-related diseases; low-cost housing construction using materials that withstand flooding; methods of grain storages; and early warning and advisories about flooding hazards.

DEVELOPMENT AND DEPLOYMENT OF ELECTRONIC ADAPTATION MANAGEMENT INFORMATION SYSTEM

The CHAI project developed an information and communication system employing a mix of technologies to facilitate gathering, storing, analyzing, and sharing climate- and weather-related data from fixed weather stations and market outlets. The system has the following functional capabilities.

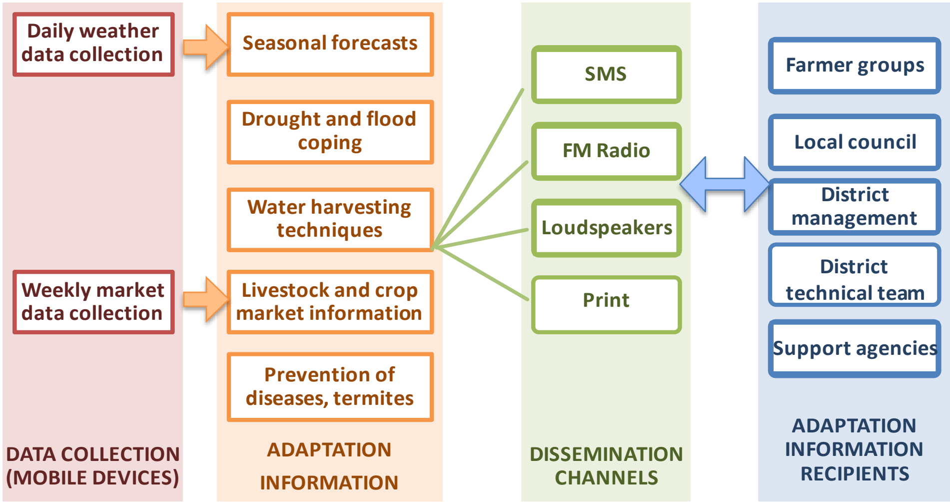


Figure 6 Overall configuration of the adaptation information system

Weather and market data collection and reporting: The availability of limited observational rainfall data was a major impediment to improving the accuracy of forecasts. There were only 12 rain gauges in the three intervention districts while the need was for 22. The project, in collaboration with the Meteorology Department, installed 10 new rain gauges to ensure that each sub-county was adequately equipped. Weather recorders based at sub-county level used mobile phones provided by the project to collect and transmit daily weather data. Community Development Officers based at sub-counties gathered and transmitted market data from 46 market outlets in the intervention districts using mobile devices. Weather and market data sets were transmitted via the cellular network and integrated into a database on a server installed by the project at the Meteorology Department in Kampala. The server automatically generated weekly market reports for dissemination to target communities. The CHAI system allowed the Meteorology Department weather forecasters to access daily rainfall data on a secure web site. Forecasts were regularly updated based on the performance assessment of the models.

Information dissemination channels: Channels used were appropriate for the different community groups. Adaptation information was disseminated to communities using Short Message Services (SMS) on mobiles, FM radio broadcasts, community loudspeakers, print and email. The capabilities of the SMS platform developed by the project included contact management; message scheduling; delivery tracking; and soliciting feedback from the communities. Recipients of text messages could respond to the system with follow-up questions or requests for additional information. The use of diverse means of communication, in addition to reaching a larger number of communities, would enable the project to assess the relative efficacy of each of the communication options.

Institutional framework for information dissemination: 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 Meteorology Department's and Local (district) Government's respectively. The generation of adaptation information has been mainstreamed into the business processes of pertinent institutions such as the Meteorology Department; CCU; district based farmer support agencies such as Production, Water, National Agricultural Advisory Services (NAADS), Natural Resources Management, Community Development, Commerce, and Communications Departments.

Adaptation Information recipients: The project disseminated localized seasonal forecasts, weekly local livestock and crop market data, low-cost rainwater harvesting techniques, and drought and flood coping mechanisms. SMS broadcasts were targeted to specific farmer groups, community leaders, district technical officers, and politicians from local councils. In Uganda, farmer groups play an important role in knowledge exchange, access to markets, agricultural inputs and credit, and dissemination of innovative agricultural technologies. The 5-year Agriculture Sector Development Strategy and Investment Plan (DSIP) recognized the vital role of farmer groups to the transformation of agricultural processes (MAAIF 2010). The groups receiving adaptation information through SMS included cattle keepers and coffee, food crop (beans, maize, bananas, sorghum, etc), and fruit tree farmers. The farmer groups served as an important interface between the project and individual farmers for sharing adaptation information and knowledge.

Linking with action resources: Information delivery using ICT tools alone cannot provide a meaningful contribution to development if the communities do not have the necessary support structures to help them translate adaptation information into action. The project identified support agencies that have the resources to help communities transform the acquired knowledge into action, and included their contact information in the district when broadcasting adaptation information through SMS and FM radio so that community members with mobile devices could easily communicate with them and get the support needed to apply the knowledge acquired through the system.

CONCLUSION

Evaluation of the hazards and the exposure of communities and their assets to the impacts of the hazards, assessment of the adaptation information and communication needs of the communities, and identification of the preferred communication channels and trusted sources of information enabled the project to develop and package appropriate adaptation information for the target communities. However, meaningful and lasting benefits may not be accrued through the delivery of adaptation information alone as communities need access to resources to assist in translating information into decision-making and action. The projected temperature and rainfall increase in the pilot districts will likely result in the increased occurrence of extreme events such as droughts and floods. While a detailed phenological review of the crops is recommended to determine how the projected changes would affect the growth cycle of each of the major crops in the districts, it is clear that rising temperatures and haphazard and increased rainfall would proliferate the risk of pest infestations, plant and animal diseases. The project established ICT tools and processes for linking communities with agencies that have the resources to help them transform their knowledge into action. The results of the analysis of adaptation information and communication needs of individuals and communities was used to design the ICT tools and tailor key adaptation messages in ways that were comprehensible and relevant to their lives. The impact of the information and communication system in enhancing the adaptive capacity of communities will be assessed in 2014. However, encouraging preliminary feedback from communities receiving adaptation information showed that they made better selections of crop seeds suited to the season and decided when, what, and where to sell their agricultural products to improve their livelihood.

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