# Climate services for agriculture in Rwanda

## Baseline survey report

Working Paper No. 202

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Jeanne Y. Coulibaly
Eliud A. Birachi
Desire M. Kagabo
Mercy Mutua


USAID
FROM THE AMERICAN PEOPLE


RESEARCH PROGRAM ON
Climate Change, Agriculture and Food Security


Working Paper

# Climate services for agriculture in Rwanda

## Baseline survey report

Working Paper No. 202

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Jeanne Y. Coulibaly, Eliud A. Birachi, Desire M. Kagabo, Mercy Mutua

**Correct citation:**
Coulibaly JY, Birachi EA, Kagabo D.M., Mutua M. 2017. Climate services for agriculture in Rwanda: Baseline survey report. **CCAFS Working Paper no. 202.** Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), led by the International Center for Tropical Agriculture (CIAT), brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. www.ccafs.cgiar.org

This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements. For details please visit https://ccafs.cgiar.org/donors. The views expressed in this document cannot be taken to reflect the official opinions of these organisations.

**Contact:**
CCAFS Coordinating Unit - Faculty of Science, Department of Plant and Environmental Sciences, University of Copenhagen, Rolighedsvej 21, DK-1958 Frederiksberg C, Denmark. Tel: +45 35331046; Email: ccafs@cgiar.org


CCAFS **Working Paper no. 202**

# Abstract

This report presents analysis of a baseline household survey for the Rwanda Climate Services for Agriculture project – a four-year, USAID-funded initiative that seeks to benefit Rwanda's farming communities and national economy through climate services and improved climate risk management. The survey intends to provide a baseline assessment of the state of climate services among agricultural households in Rwanda. A random sample of 3,046 respondents was nationally surveyed in the all four provinces of the country and in the city of Kigali. A total of 52% of the sample were female respondents, while two-thirds of the households interviewed were male-headed households. The baseline includes outcome indicators related to access, use of climate information, channels of communication, behavioral change and perceived livelihood benefit/impact. The project evaluation will involve assessing changes over time in these benchmark indicators and eventually comparing the changes across beneficiaries and non-beneficiaries. A qualitative component of the evaluation will provide deeper insights into users' decision making, behavioral change and any socially differentiated effect.

According to the survey, seasonal and indigenous climate forecasts are the main climate information that respondents are aware of, with women being less aware of climate information than men. The content of climate information currently disseminated includes the more traditional information. These are onset of rains, risk of extreme events and daily precipitation. Climate information is disseminated to respondents, but indigenous climate forecasts are still provided at the national or district scale, limiting the relevance for farmers' decision making.

In all districts surveyed, respondents have little access to specific types of climate products, particularly in Kigali and the Northern Provinces. The most common types of climate information products accessed are forecasts for onset of rains, seasonal forecast, daily weather forecasts and forecasts for extreme events. But this access is very variable across districts (as high as 30% of the respondents in the Eastern Province and as low as 2% of the respondents in Kigali Province). Historical climate information and early warnings are received by respondents very infrequently. Overall, men have significantly greater access to climate

information compared to women as their awareness and knowledge of climate information is also greater.

Radio is by far the main communication means of climate information in all provinces as stated by at least 74% of the respondents. This is followed by government extension agents, neighbors and farmer-to-farmer communication. Information dissemination through cell phones is almost non-existent, although a cell phone is the most common communication asset owned by respondents followed by radio. This implies that there is vast opportunity to reach a large audience of farmers through interactive radio programs and cell phone-based climate information.

Ability to use climate information is very variable across provinces. The Western Province has the highest proportion of respondents who claimed to be able to use climate information while the Northern Province records the lowest proportion. Beyond poverty status, which is correlated with ability to use climate information, lack of trust in the information provided and lack of locally relevant climate information have been cited as the main constraint preventing extensive use of these products. A small percentage of respondents actively seek climate information and question the relevance of the information that is currently routinely available. Current use of climate information has little influence on farmer decision-making. It is therefore expected that planned improvements in climate information will result in behavioral change and enhanced resilience if the information is tailored to meet the needs of the agricultural community.

Generally, the benchmark level for resilience is also low, between 0.2 and 0.3 (see annex 3 for details on the benchmark index). Variability across provinces is driven by factors such as differences in livelihood systems, and social and institutional capacity.

**Keywords**

Climate information; Seasonal climate forecasts, Climate risk; Resilience; Communication; Agricultural extension; Radio; ICT; Mobile phones

# About the authors

**Jeanne Y. Coulibaly** is a scientist, agricultural economist working for the World Agroforestry Center (ICRAF) based in Nairobi, Kenya. Dr. Coulibaly's work focuses on the economics of adaptation to climate change with a particular focus on climate information services, agroforestry technologies and their contribution to households' well-being. Contact: J.Coulibaly@cgiar.org

**Eliud Abucheli Birachi** is a scientist, market economist working for the International Center for Tropical Agriculture (CIAT) based in Kigali, Rwanda. Dr. Birachi's work focuses on smallholder market access and livelihood strategies. Contact: e.birachi@cgiar.org

**Desire M. Kagabo** is a scientist, focusing on farming systems and climate services and works for the International Center for Tropical Agriculture (CIAT) based in Kigali, Rwanda. Dr. Kagabo's work helps transform Rwanda's rural farming communities through improved climate risk management. Contact: d.kagabo@cgiar.org

**Mercy Mutua** is a statistics and data management specialist, working for the International Center for Tropical Agriculture (CIAT) based in Nairobi, Kenya. Ms. Mutua's work focuses on statistical design, capture and analysis of social and economic data of smallholder farmers. Contact: mmutua@cgiar.org

# Acknowledgements

This report has been made possible through support from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); the World Agroforestry Center and the International Center for Tropical Agriculture (CIAT). We would like to express our appreciation to the Rwanda national institutions for their great support: Firstly, thanks to the Rwanda National Ethics Committee for granting the research approval. Secondly, we would like to express great appreciation to the National Institute for Statistics of Rwanda that facilitated the process of random sampling of sectors, cells and villages in which the baseline survey was conducted. Thirdly, we offer special thanks to the Rwanda Agriculture Board and Dr. Daphrose Gahakwa for endorsing the baseline survey study and recommending the study to the Ministry of Education for approval. Next, Mr. John Ntanganda and staff of Meteo Rwanda (the Rwanda Metrological Agency) gave useful insights into various climate issues relevant for the survey. Special appreciation goes to RAB extension staff in all the districts, all levels of district, sector, cell and village administrators where the households were sampled and surveyed for their organisation and efficient logistics without which the survey would not have been possible.

The authors express their appreciation to the survey leadership team (Eliud Birachi, Jeanne Coulibaly, Mercy Mutua, Desire Kagabo and Gloriose Nsengiyumva); to James Hansen, Peter Dorward, Graham Clarkson, Henry Neufeldt, Enid Katungi and Maren Radeny for their technical expertise and guidance; and to Bora Divine and Chantal Ingabire for operational and logistical support. Special thanks go the team of enumerators and their supervisors. In addition, we offer special thanks to CIAT Rwanda country office led by Joseph Mulambu for the smooth facilitation and logistical support of the entire exercise. We are also grateful to Lili Szilagyi, Catherine Mungai, James Hansen and Alison Rose for editorial work that went into finalizing the report. Finally, we express our gratitude to USAID. This study was made possible by the generous support of the American people through the United States Agency for International Development (USAID). The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of USAID or the United States Government.

# Contents

# Acronyms

| | |
|---|---|
| CCAFS | Climate Change, Agriculture and Food Security Programme of CGIAR |
| CIAT | International Center for Tropical Agriculture |
| ICRAF | World Forestry Center |
| ICRISAT | International Crop Research Institute for the Semi-Arid Tropics |
| IRI | International Research Institute for Climate and Society |
| NISR | National Institute of Statistics of Rwanda |
| PICSA | Participatory Integrated Climate Services in Agriculture |
| RAB | Rwanda Agriculture Board |
| SEDOs | Socio-Economic Development Officers |

# Introduction

Rwanda Climate Services for Agriculture is a four-year USAID-funded project designed to empower farmers in the management of climate risks to achieve greater resilience to climate change. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is the principal coordinating agency of the project, with active involvement of other international and national implementing partners. International institutions include global experts in climatology and climate services from the International Research Institute for Climate and Society (IRI) of Columbia University, the International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical (CIAT)), the University of Reading, Farm Radio International, the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and the World Forestry Center (ICRAF). National partners are spearheading the implementation of the project on the ground to ensure sustainability of the activities. These partners encompass Rwanda Meteorological Agency (Meteo-Rwanda), Rwanda Agriculture Board (RAB), NGOs, farmer cooperatives, rural radio networks and ICT service providers.

The project seeks to provide farmers across Rwanda's 30 districts with tailored climate information and related advisory services, and help them to effectively use the information to manage climate risk in their production decisions. The long term objective of this project is to increase climate resilience through increase in food security. To achieve this goal, the project's central program will revolve around a number of capacity building activities targeting national partners including Meteo-Rwanda, RAB and agricultural extension staff, rural radio networks, ICT providers will be undertaken to create relevant climate services that can support farmers, rural planners and policy makers in their decisions under uncertain climate changes.

Dissemination of climate services will be done at scale in order to build a national climate services system that links the national meteorological services to the end-users. This will involve effective and functioning agricultural extension services that will be based on the training of trainers to reach farmers in remote villages, delivery of radio broadcast and cell phone SMS on improved climate services at national scale. Users' feedback will also be expected from the weather and climate products that will be delivered to ensure co-production

and tailored climate services to end-user needs. Enhanced delivery of climate information, agronomic services and farmers' education on climate risks will result in increased knowledge of climate impacts by farmers, improved farm decision-making, adoption of climate smart technologies and increased agricultural productivity, which, in the long term, will translate into increased resilience to climate risks.

The project has four main work packages, defined in terms of end-of-project outcomes, and target different levels of beneficiaries from farmers to government decision-makers (Table 1). The impact assessment strategy reported in this document is focusing at the grassroots level of implementation.

**Table 1. Description of the project work packages**

| Outcome | Description |
|---|---|
| 1.Climate services for farmers | Agricultural extension and other relevant intermediary organizations and communicators provide farmers[1] across Rwanda's 30 districts with decision-relevant operational climate information and advisory services, and empower and guide them to use the information and better manage risk |
| 2.Climate services for government and institutions | Agricultural and food security decision-makers in the Ministry of Agriculture, and in other relevant government agencies and institutions, are using climate information to respond more effectively to climate-related risks and to inform decisions that build the resilience of farmers |
| 3.Climate information provision | Meteo-Rwanda is designing, delivering, and incorporating user feedback into a growing suite of weather and climate information products (historic, monitored, forecast) and services tailored to the needs of agricultural and food security decision-makers |
| 4.Climate services governance | A national climate services governance structure ensures sustained co-production, assessment and improvement of climate service for agriculture and food security; and facilitates a formal interface and effective dialog between the key agencies[2] involved |

# Methods

The evaluation approach is guided by the main evaluation questions the project is expected to answers. The questions aim both to evaluate the project's impact, provide evidence of progress on indicators required by the donor. The evaluations questions are:

[1] At least 40% of beneficiaries are female farmers, with an emphasis on the youth.

[2] Expected to include at least: Meteo-Rwanda (climate information provider), the Ministry of Agriculture (decision-makers) and the Rwanda Agriculture Board (research and extension service)

- What is the rate of access and use of climate services in the local community?
- What factors influence the use of climate information at the farm level?
- To what extent do agricultural households adapt their farm management decisions as a result of greater uptake of climate services?
- What are the main behavioral changes in response to the uptake of climate services by farmers?
- What is the effect of training of peer farmers and sector agronomists on farm management decisions?

The indicators required by USAID, disaggregated by gender, are (USAID Office of Global Climate Change, 2016):

- Number of people using climate information or implementing risk-reducing actions to improve resilience to climate change as supported by United States Government (USG) assistance;
- Number of people supported by the USG to adapt to the effects of climate change; and
- Number of people trained in climate change adaptation supported by USG assistance.

To answer these questions, the evaluation approach is based on a mixed method design that combines quasi-experimental and descriptive approaches. The quasi-experimental design will involve comparing changes over the project between project participants and non-participants. It is a more conventional approach in impact assessment that helps to measure the changes in outcomes as the result of the project interventions. This design will use a difference in difference methodology complemented by a Propensity Score Matching technique that ensures similarity between the program participants and non-participants for a set of observed characteristics.

However, given the national scale of the project implementation where it is expected that the project will reach a majority of farm households at the end of its life time, a conventional approach may not be feasible to implement due to inability to isolate a true comparison group at the end of the project. But the timing of access, for example for the Participatory Integrated Climate Services for Agriculture (PICSA) training, can be used to isolate a comparison group.

In a district, the training will start in three sectors in the first years and will target farmer promoters, Socio-Economic Development Officers (SEDOs) and Sector Agronomists as trainers who will be directly trained by the project implementers. The training will expand gradually in the remaining sectors of a district and involve communities that will benefit indirectly from the outcome of the training of trainers. The treatment group will be constituted of farmers in the sectors that will receive the training from the lead trainers and the comparison group will include those who will be phased in later years. But this comparison group will only be temporary given that at the end of the project, everyone will be granted access to the interventions. This highlights the importance of collecting yearly data to assess changes in behavior between these two groups.

Since the training has already started in some sectors, the treatment sectors will include sectors that have not benefited from the intervention and will be reached in the 2017 agricultural season starting in September and lasting through December 2017.

For other program activities such as radio and SMS broadcasts that will be delivered at a national scale on the go, a sample before and after assessment will be used to capture their effects on livelihoods.

The quasi-experimental design will be supplemented by a qualitative assessment that will provide a more in-depth understanding of the pathway to impact and a comprehensive understanding of the program's effectiveness. It will be based on providing a description of the socio-cultural and institutional context of the program, collecting information on livelihood challenges that mitigate or hamper the impact of climate services, documenting how the program has changed the behavior of participants and made any effects on their livelihoods. This will be done through analysis of secondary data, monitoring reports, focus group discussions and key informant interviews for the project participants.

## Sampling strategy

The sampling strategy was based on a multi stage process. Given that the project is expected to be nationwide, all 30 districts in Rwanda were our population of interest. In each district, two sectors were randomly selected and in each sector three villages were randomly selected. One of the sectors in the districts will be directly trained in the period of the project while the other will be indirectly trained. Cells and households in each sector have been selected with

the assistance of the National Institute of Statistics and Research (NISR). The sampling frame was provided from village-level administrative leadership based on the identified sample villages. The population consisted of farmers (livestock and crops), men and women household decision makers, as well as decision makers in climate. Households were proportionally and randomly selected in each village to achieve a target of 3046 farming households (Table 2).

**Table 2. Sample distribution of the surveyed**

| Province | Number of districts | Number of sectors | Number of cells | Number of villages | Number of farmers |
|---|---|---|---|---|---|
| North | 5 | 9 | 27 | 30 | 509 |
| South | 8 | 15 | 43 | 48 | 808 |
| East | 7 | 14 | 32 | 42 | 714 |
| West | 7 | 14 | 39 | 42 | 710 |
| Kigali | 3 | 6 | 15 | 18 | 305 |
| Total | 30 | 58 | 156 | 180 | 3046 |

Figure 1 presents the percentage of male and female respondents interviewed in each province. As we can see, the samples of respondents were almost equally distributed across gender with slightly more females interviewed in all provinces except the Northern Province.

Further, Figure 2 shows that more than two-thirds of the respondents interviewed were the heads of their households and almost one-third were the spouses of the household heads. On average, 85% of the respondents were male household heads.

**Figure 1. Percentage of males and females respondents by province**

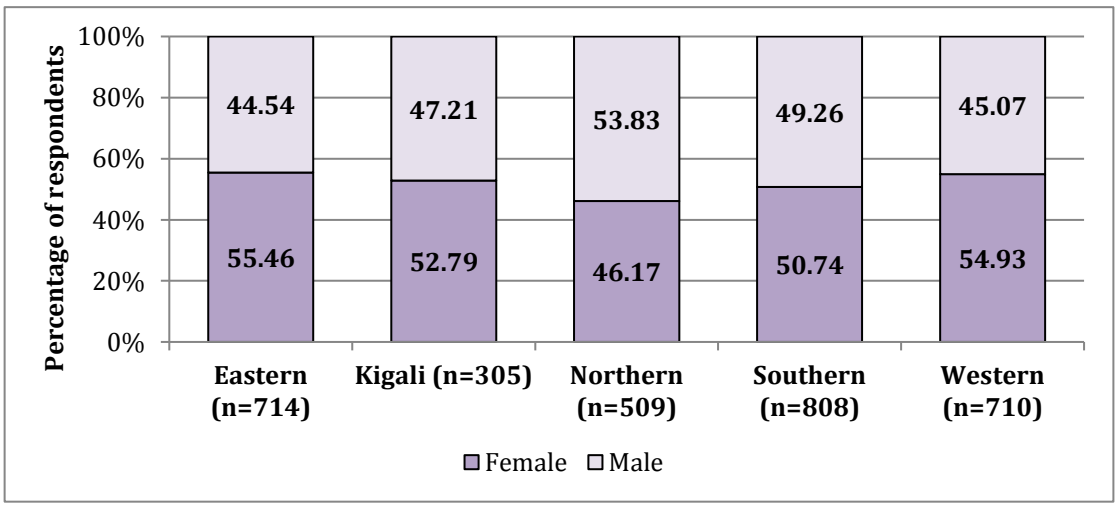
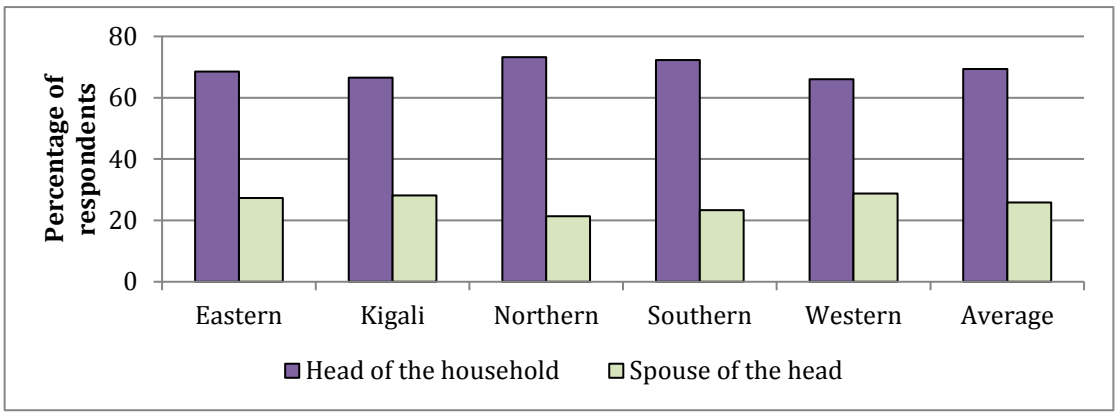


**Figure 2. Percentage of household heads and their spouses interviewed in each province**




## Survey instruments and data analysis

A household survey instrument was developed to capture data on the outcome indicators. The questionnaire included sections on household's socio-economic characteristics, climate risk awareness and coping mechanisms, awareness of climate information, access and use of climate information, behavioral change and perceived impact. The questionnaire was reviewed by all the project team members, edited, approved and translated in the Open Data Kit (ODK) system by the ICRAF and CIAT teams on the survey. The questionnaire was translated into Kinyarwanda by the CIAT team in Rwanda and used to train a team of enumerators in Kigali. Based on field feedback, the questionnaire was edited and formatted by CIAT team to improve the flow in the questions.

The survey is based on the hypothesis that behavior changes as a result of provision of climate forecasts is highly correlated to the rainfall season which is stochastic and varies from year to year. It is therefore important to track changes in behavior associated with the delivery of climate forecast yearly for each rainfall season to inform on the program's effectiveness.

The survey was administered to men and women decision makers in 30 districts of Rwanda, focusing on 180 villages identified in collaboration with the National Institute of Statistics of Rwanda (NISR) who provided the latest sampling frame and sample selection.

Data was collected using the computer-assisted personal interviewing (CAPI) technique in ODK software between September and October 2016 over a period of three weeks. Daily checking and quality management was conducted by CIAT through the online data

transmission system to ensure that any errors are corrected as soon as possible. Data cleaning was then conducted on the entire dataset before analyses.

Descriptive analysis using STATA statistical software was done. Analysis was disaggregated across provinces but whenever possible across gender to differentiate some benchmark indicators across females and males and monitor in the next years the improvements that the project will make on these indicators across gender.

# Results

## General household characteristics

Data was collected on general household characteristics to have a comprehensive picture of the socio-economic status that can influence access and use of climate services. This socio-economic information is part of the contextual environment which shapes farmers' decision making and their ability to respond to climate information.

### Respondents' demographics and livelihood options

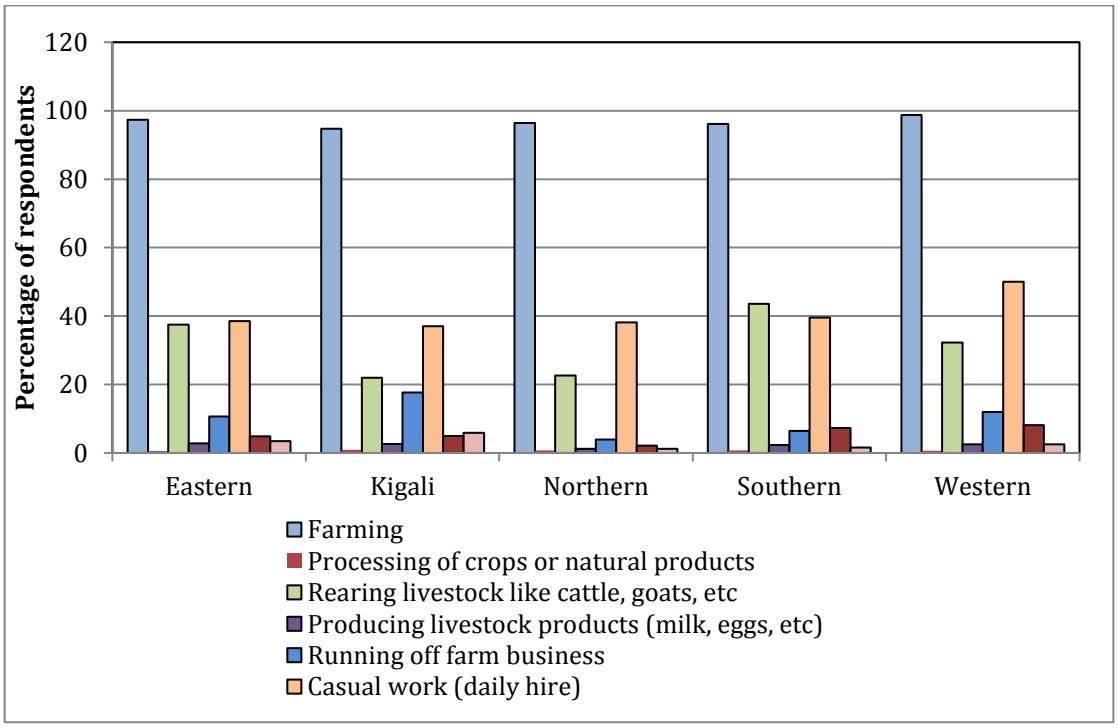
Table 3 reports the results of the main socio-economic characteristics of the respondents and the heads of the households. Other additional characteristics are presented in table 5 in terms of averages. Figure 3 details livelihood options pursued by the respondents. More than two-thirds of the respondents interviewed were the heads of their households and almost one-third were the spouses of the household heads. These household heads were in most of the cases married and living with their spouses. In terms of education level, on average 35% of the household heads have at least six years of education, so have completed primary education. This percentage is almost the same across provinces. Further, around half of the respondents reported that their female spouses or female head of the households are literate in some written languages. Households are composed of relatively young members with only 16% of the members being above 64 years old. Cropping farming is the main occupation for two-thirds of the households interviewed except in the Southern Province where only 47% of the households are involved in this activity. In the Southern Province, a relatively higher percentage of households are involved in agro-pastoralism compared to the other provinces. Overall, farming including crop production and livestock rearing is the most commonly

reported livelihood activity undertaken by around 95% of households interviewed as displayed in Figure 3.

**Table 3. General characteristics of the households (percent)**

| Characteristic | Eastern | Kigali | Northern | Southern | Western | Average |
|---|---|---|---|---|---|---|
| Household members over 64 | 14.99 | 14.75 | 16.9 | 15.72 | 15.92 | 15.66 |
| Female literacy | 55.88 | 66.89 | 49.51 | 57.43 | 53.1 | 56.56 |
| at least 6 years of education for the HH | 36.55 | 39.67 | 36.74 | 33.91 | 32.39 | 35.85 |
| Married | 71.01 | 76.72 | 72.5 | 69.06 | 75.07 | 72.87 |
| Crop Farmer | 67.65 | 65.9 | 72.69 | 47.15 | 61.55 | 62.99 |
| Agro-pastoralists | 24.23 | 16.72 | 20.04 | 41.46 | 28.87 | 26.26 |
| Off-farm business | 10.64 | 17.7 | 3.93 | 6.44 | 11.97 | 10.14 |
| Agricultural extension visits | 28.99 | 12.13 | 23.97 | 23.39 | 25.92 | 22.88 |
| Membership in association for the HH | 53.36 | 44.26 | 51.67 | 44.93 | 45.63 | 47.97 |
| Membership in association for the spouse of the HH | 24.65 | 28.85 | 26.92 | 31.44 | 24.93 | 27.36 |
| Land ownership | 92.02 | 87.54 | 95.48 | 93.19 | 97.32 | 93.11 |
| Irrigation | 7 | 14.75 | 6.48 | 11.88 | 7.75 | 9.57 |

**Figure 3. Livelihood options pursued by households**




Regarding off-farm activities, the statistics show that very few households are running off-farm business, with the lowest percentages obtained in the Southern and Northern Provinces.

Less than one-third of the households interviewed received agricultural extension visits but those who benefited from extension visits were visited quite frequently, on average four times a year (mean number not reported here).

Generally household heads are members of associations, more frequently than their spouses. The most common associations for most of the households are producer/livestock group and credit/microfinance association. These are also the most common types of associations represented in the surveyed provinces. The overwhelming majority of households surveyed own land, mostly through title deeds. However, the technology of irrigation is not common among rural households in Rwanda, with less than 10% adopting this practice.

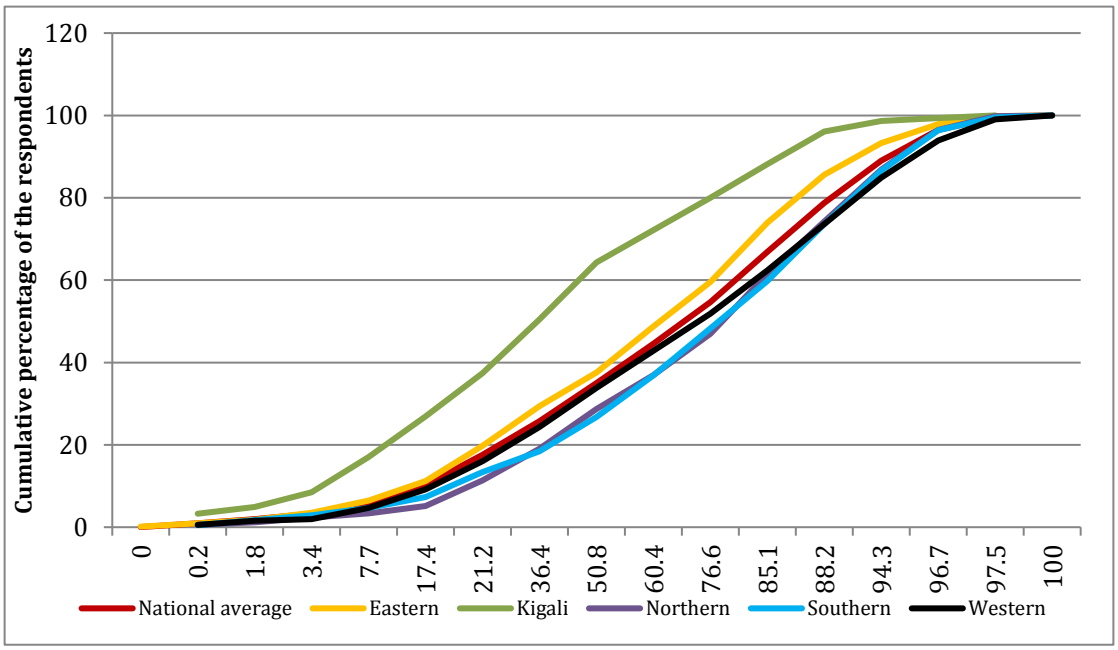
The average age of the household heads surveyed in Rwanda is 47 years old, with an average of four years of education (Table 4). As expected, the highest number of education years is in the province of Kigali (4.16) and the lowest number is in the Northern Province (3.39). The sizes of the households, mostly characterized by nuclear families are relatively small, between four and five adults with two of them being productive. Areas of land cropped or cultivated are also small, less than 0.5 ha.A high population density in Rwanda, the highest in Africa, puts pressure on land resource and limits the land size that can be accessed by households. Irrigation is practiced on less than 0.25 ha of land for households that use this technology. Expansion of land holding and shift to irrigated systems may not often be the only feasible investment alternatives (land is already scarce and irrigation can be costly) in response to climate forecasts. More intensified strategies (enhanced crop yield technologies such as improved crop seeds, organic/inorganic fertilizer, water retention practices) may be more viable options to respond to climate information. But increased adoption of these latter options is also related to access to financial capital.

### Poverty status

The poverty status of the households in the districts surveyed was assessed using the Progress Out of Poverty Index developed by Schreiner (2010). Following this methodology, scores were calculated for each household based on a list of 10 indicators of poverty related to household consumption, education, housing, and ownership of durable assets and provided in the Simple Poverty Score Card of Rwanda. The scores were then converted into a likelihood that a household has a poverty line below the threshold of USD 1.25 per day. These estimates will be useful to track changes in poverty rate over the project life across districts. Results are

differentiated across provinces and are represented in Figure 4 below. This figure depicts the cumulative distribution of the Poverty Index for the surveyed households in the different provinces. Unsurprisingly, the province of Kigali and the Eastern Province are above the national average, which means that they fare much better, with the highest number of households having less likelihood to be poor relatively to the other districts. These results support findings from the national statistics bureau that identified Kigali and the Eastern Province as the least poor provinces in three rounds of household surveys (NSIR 2012). These provinces benefit from infrastructure development, more urbanization, proximity to neighboring countries and a prosperous market of Kigali city, all of these may contribute to alternative employment opportunities, improve consumption levels and lessen poverty. The Northern, Southern and Western Provinces have the highest numbers of people with the likelihood of being poor. For example, 60% of the households surveyed in the province of Kigali have 36% chance to be below the poverty line of USD 1.25 a day while in the northern and the Southern Provinces the same percentage of households has 85% chance to be below the poverty threshold.

**Figure 4. Cumulative distribution of the Poverty Index across provinces**




## Communication assets

Results of the communication assets owned or accessed by the households are presented in Figure 5. The most widely spread communication assets across provinces is a cell phone,

owned by a minimum of 54% of respondents in the Southern Province to a maximum of 78% of respondents in Kigali Province. Radio comes in second, with barely half of the households interviewed owning this asset except in the province of Kigali where a larger percentage of households, 60% owns a radio. Television is owned by less than 10% on average of the households interviewed. These results suggest that cell phones need to be considered as a top channel to reach most of the beneficiaries, and, coupled with radio, has highest potential to reach a wider audience. A slight advantage of radio is that it is shared in the household and information communicated through this medium can reach several family members at once as illustrated in Figure 6 and 7.

Indeed, respondents were asked about household members that own, have accessed to or mostly use the communication assets. Focusing on the main communication assets identified above, there seems to be a more equitable ownership, access and use of radio by male and female spouses within households (Figure 6) and this is consistent across the provinces. Regarding cell phones, male spouses appear to be the main owners and users of this asset in the Northern and the Western Provinces, while in the other provinces, the ownership, access and use of cell phones is more equitably distributed over spouses.

Given the popularity of cell phones and radio among the surveyed households, there is ample opportunity to develop interactive radio programs where listeners could participate by calling in to have more explicit and detailed information.

**Figure 5. Ownership of communication assets across provinces**

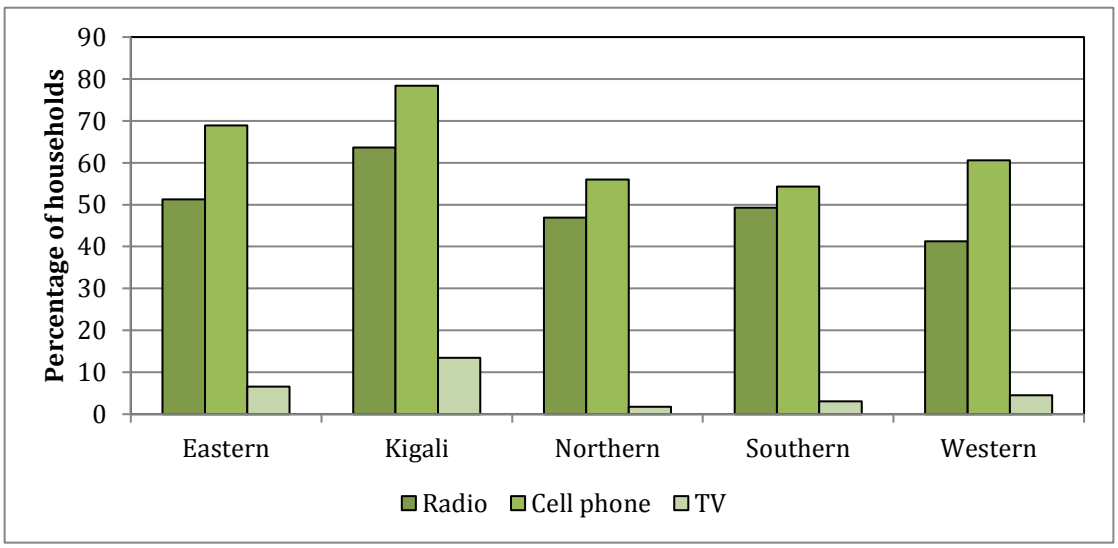


**Figure 6. Ownership, access, use of radio within households**

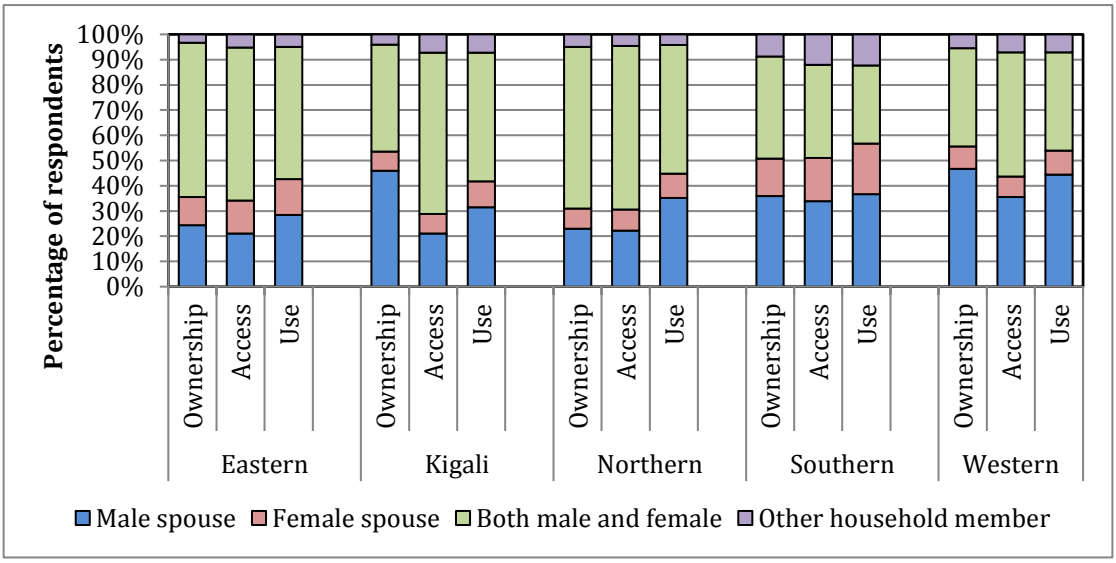



**Figure 7. Ownership, access, use of cell phones within households**


## Climate risk awareness and coping mechanism by acro-ecology

### Awareness of climate change

Awareness of climate change is a necessary prerequisite to adaptation (Maddison 2007). A number of studies on adaptation to climate change have shown that perceptions on climate change influences farmers' decision to adapt (Bryan et al. 2009; Deressa et al. 2011). To

capture respondents' awareness of climate change, households were first asked about the extent to which they have heard about it. Figure 8 displays the results of this assessment. Most respondents, ranging from 64% in the Eastern Province to 87% in the Southern Province, have either not heard at all about it or have heard only little about it. This highlights the need to raise more awareness to climate change issues to support households' adaptation to climate change.

Further, when asked about their perceptions of change in climate over the past 20 years, more than half of the respondents agree that the climate is becoming hotter, with shorter rainy seasons, and an increased number of dry spells and drought (Table 5). These perceptions corroborated the general rise in temperature, particularly since 1992 and the predictions of climate change scenario models that show future increase in mean annual temperature (SEI 2009). They are also aligned with some empirical testimonies that temperature increased with high frequency of hot days, the number of annual rainfall days decreased and the number of dry spells increased (Mutabazi 2011). All these changes are likely to lead to poor crop performance and impact negatively the livelihoods if no adaptation measures are taken.

**Figure 8. Respondents' awareness of climate change**

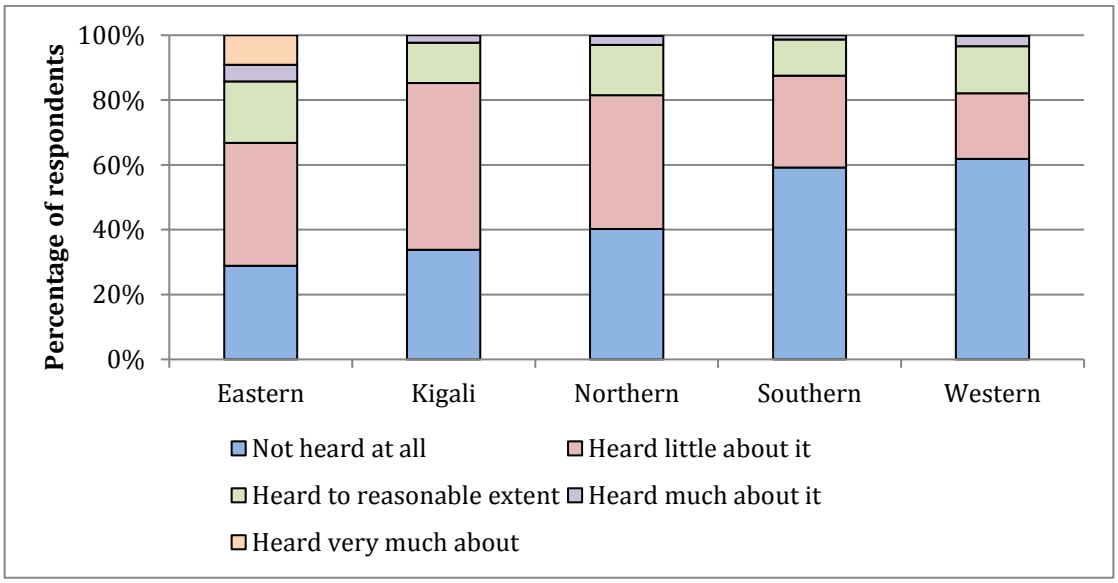


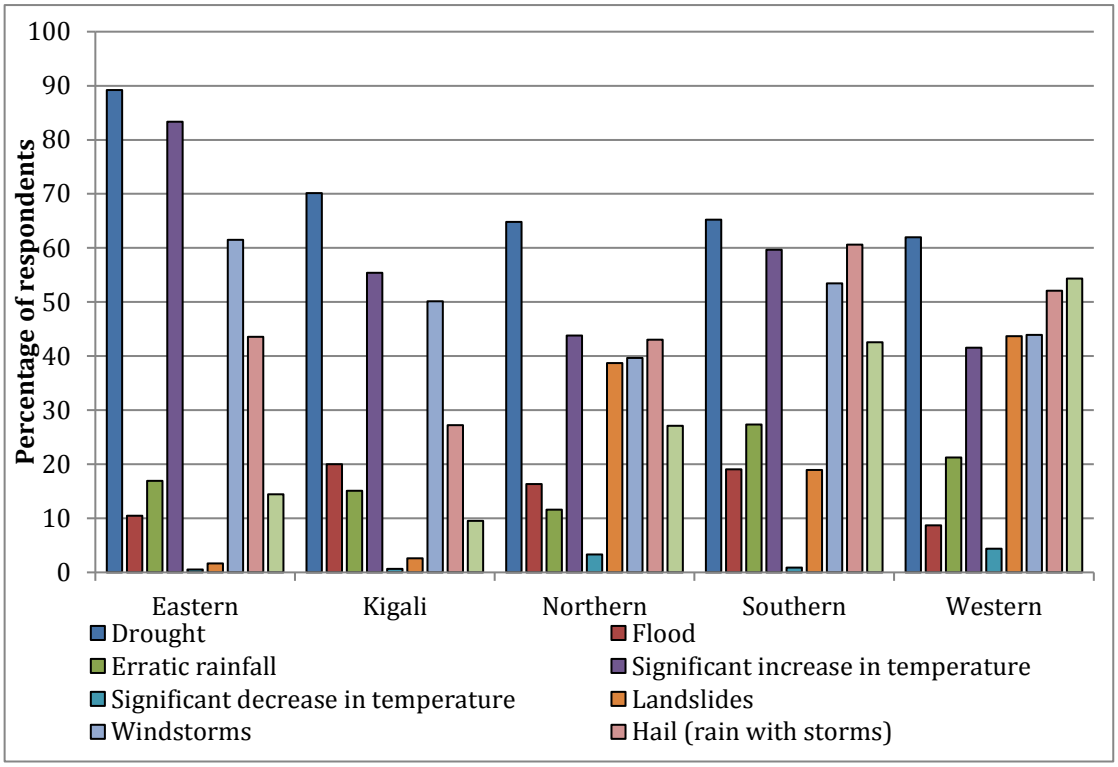
**Table 5. Respondents' perception of change in climate over the past 20 years (percent)**

| Over the last 20 years in my area | Strongly disagree | Disagree | Indifferent | Agree | Strongly agree | Do not know |
|---|---|---|---|---|---|---|
| The number of rainy days has significantly decreased | 2.72 | 9.68 | 2.99 | 60.47 | 17.89 | 6.24 |
| The number of dry spells has significantly increased | 2.59 | 8.24 | 2.79 | 61.62 | 18.78 | 5.98 |
| The number of hot days has slightly increased | 5.35 | 11.56 | 4.37 | 60.21 | 10.97 | 7.55 |
| The frequency of flood did not change | 24.36 | 31.52 | 4.92 | 21.67 | 4.2 | 13.33 |
| The severity of flood has significantly increased | 30.73 | 39.59 | 4.27 | 12.05 | 2.04 | 11.33 |
| The frequency of drought has significantly increased | 3.22 | 13.99 | 3.68 | 56.53 | 16.22 | 6.37 |
| The severity of drought has slightly increased | 4.43 | 18.98 | 4.27 | 52.17 | 13.46 | 6.70 |

## Main climate risks

Figure 9 shows that the major climate risk experienced by the respondents interviewed in all provinces is drought. This climate risk is mostly prevalent in the Eastern and Kigali Provinces where 90% and 70% of the respondents, respectively, acknowledged drought as the major extreme climate event. This is not surprising as these provinces, particularly the Eastern Province, are well recognized as prone low rainfall regions in Rwanda. The second most prominent climate risk is a significant increase in temperature as indicated by the respondents in all provinces except the Western Province. Drought is often associated with significant increase in temperature and this finding also supports respondents' perception of climate change over the last 20 years as reported in Table 5. Other main shocks in the Western, Southern and Northern Provinces are hailstorms, windstorms, soil erosion and landslides. Although flood has not been reported as a prime shock by the respondents in the three aforementioned provinces prone to flooding, the collateral effects of soil erosion -- landslides -- have been often acknowledged.

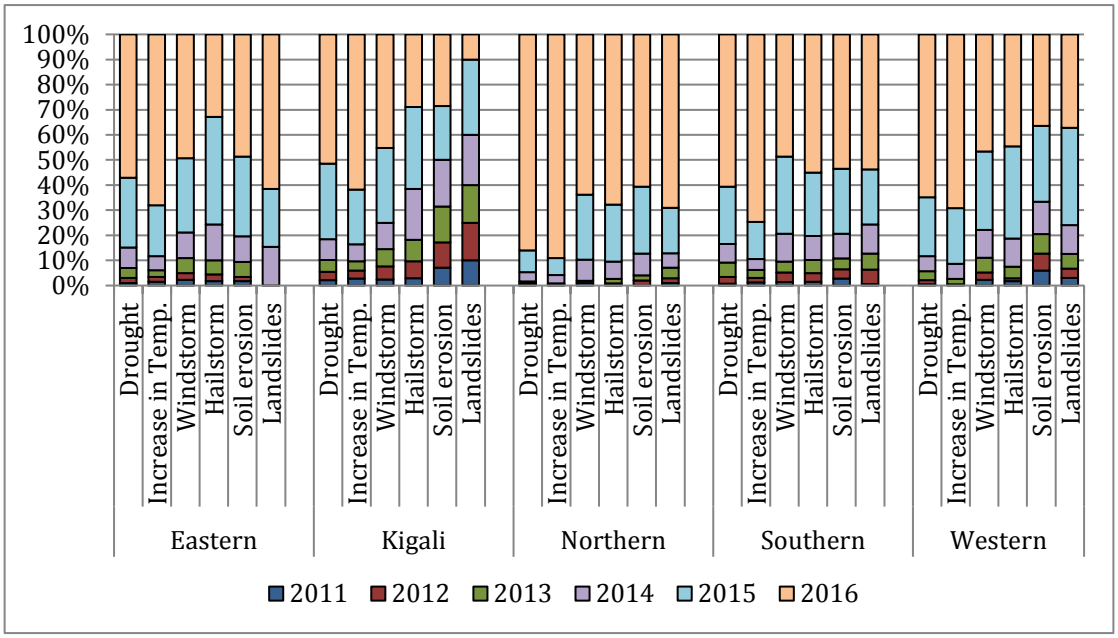
**Figure 9. Climate risks experienced over the past 5 years**




When we asked the respondents about the years when they experienced these climate risks over the past five years, the majority of respondents identified first the year 2016 and then the year 2015 as illustrated in Figure 10. However, these reports may be taken with caution or confirmed by empirical evidence as usually respondents remember more about close events compared to those that are farther in time.

Further, respondents acknowledged that generally crop production has been affected to a large or very large extent by these climate shocks as opposed to livestock production or other livelihood activities which are relatively less affected. For example 42% of the respondents revealed to have been affected by a large to a very large extent by drought when only 16% and 10% are reported for livestock and livelihood respectively.

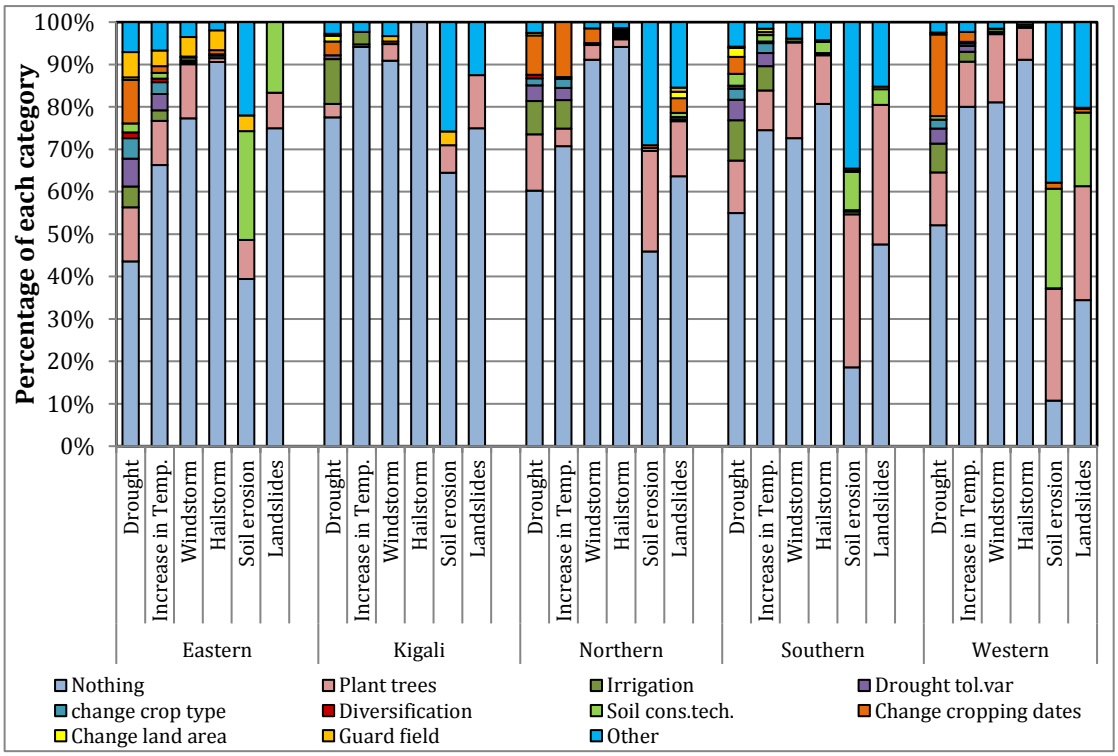
**Figure 10. Years of climate risks experiences in the provinces**




## Coping mechanisms

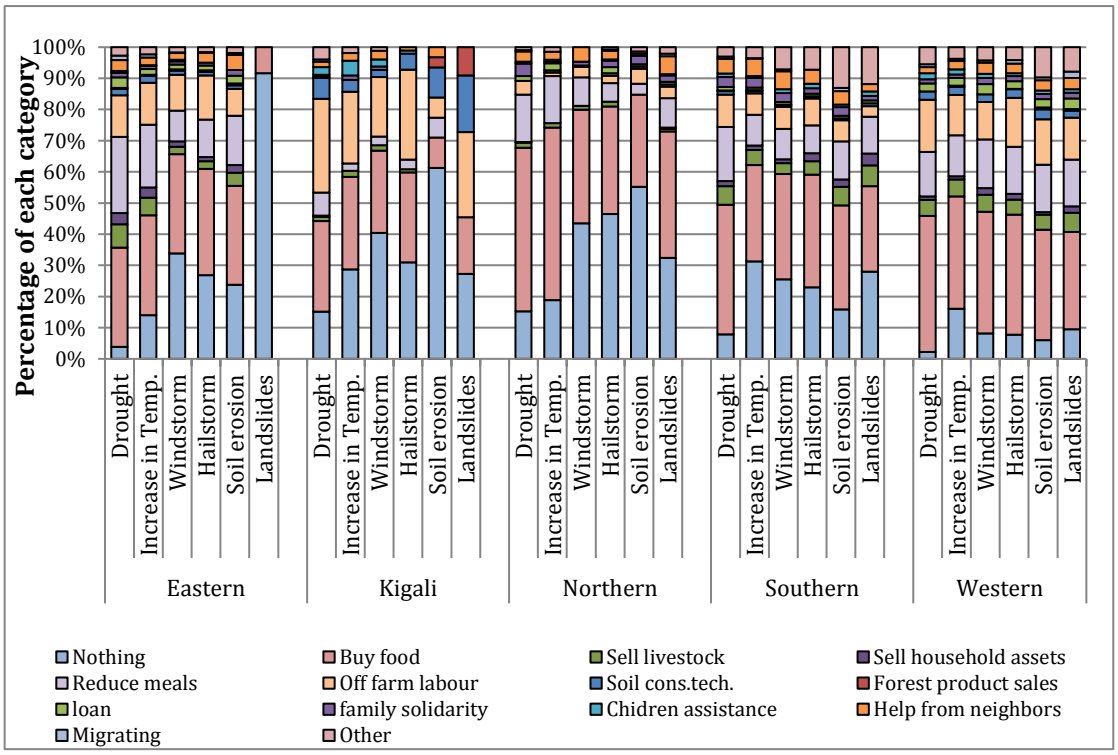
Following the reports on the main climate shocks experienced in the surveyed areas, respondents were also asked about the prevention and coping mechanisms that they used to respond to these shocks. Among the list of 11 prevention measures identified, "doing nothing" has been largely reported across shocks, particularly for windstorms, hailstorms and significant increase in temperature, this regardless of the provinces (Figure 11). For drought, when households are able to use some adaptation measures, they opt generally for planting trees, use of drought tolerant varieties, and changing cropping dates. Households reported to control soil erosion by planting trees and the use of soil conservation techniques. It is not surprising that trees stand out as a main prevention measure against climate shocks as they serve as natural wind barrier, control for soil erosion, improve soil nutrient and moisture, and sequester carbon while providing several other adaptation benefits (source of food, fodder, income and fuelwood).

**Figure 11. Prevention measures to climate shocks**




Regarding the coping mechanisms identified, Figure 12 shows that it is very common for the respondents to not engage in any strategies when confronted with climate shocks. Several potential reasons include lack of adequate resources, lack of public assistance to act, failure to have access to early warning systems and climate forecasts on time to prepare for the shock or failure to believe in the information provided. While households surveyed are largely not able to prevent climate shocks, buying food, reducing the number of meals consumed and off farm labor are the main coping measures adopted. These are often ex-post coping strategies that are not sustainable over time and may drive poor households into poverty trap.

**Figure 12. Coping mechanisms to climate shocks**




## Climate information awareness, content and uncertainty

A main objective of the project is to improve access and use of climate information. A first step in achieving this objective is to understand the types of climate information households are aware of and generally receive.

### Awareness of climate information and general climate information received

Figure 13 presents the types of information households are aware of in the provinces surveyed. Indigenous forecast that uses the knowledge built up by a group of people in a community and seasonal climate forecasts appear clearly as the main climate information the respondents are aware of. Seasonal forecasts are received as much as indigenous forecasts in the Eastern, Kigali and Western districts, with 60%, 55% and one third of the respondents respectively reporting to be aware of these two types of information. In the Northern and the Southern districts, there are large differences in the percent of the respondents who are aware of these latter climate forecasts across types of information and provinces. In the Northern district, while almost half of the respondents are aware of indigenous forecasts, only 25% are reporting awareness for seasonal forecasts. In the Southern Province, 12% of the respondents are aware of indigenous forecasts and 33% for the seasonal forecasts.

Short-term climate forecasts such as daily weather forecasts is the third most common climate information respondents are aware of. Again, a higher percentage of respondents are in the Eastern and Kigali Provinces, with around 40% being aware of this type of information compared to the other provinces. Historical climate information is unsurprisingly barely known in all provinces with an average of less than 20% of respondents reporting it. The Southern Province has the lowest scores in terms of awareness for almost all types of climate information. When we focus on the difference across gender reported in Table 6, we notice that women are significantly less aware of climate information than men, particularly for the short-term and seasonal climate forecasts in all provinces. This gap may be explained by the larger proportions of men that own the communication assets and are involved in social activities and are therefore more likely to be exposed to climate information. Increasing uptake of climate information will therefore need to build more awareness of climate information, particularly for women, and provide knowledge how they can tap into this information to improve their planning and farm management decisions. This also suggests a need to ensure greater exposure to climate information through mass media and other social networks, including participatory farmer workshops.

**Figure 13. Types of climate information households are aware of**

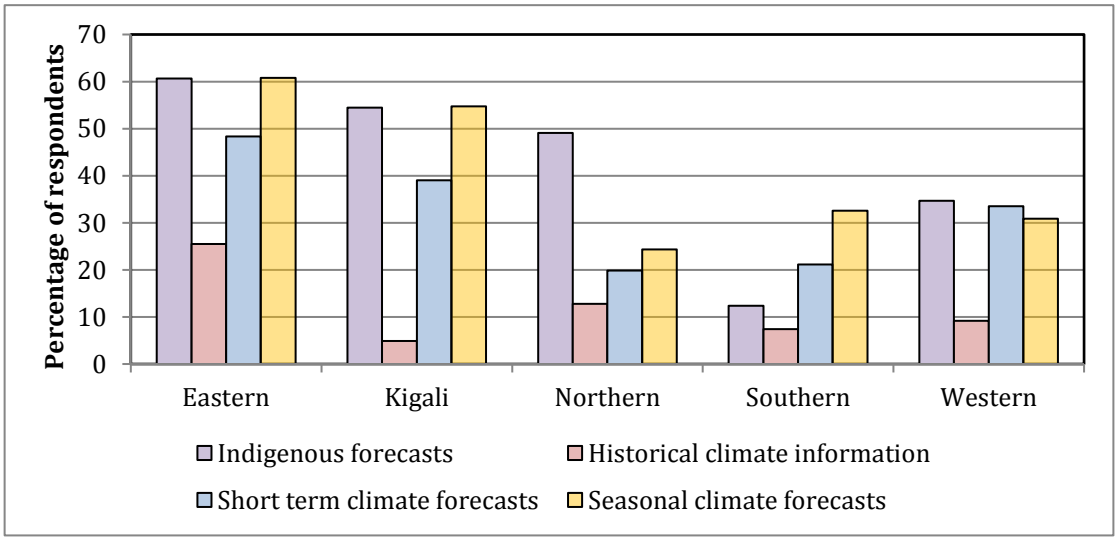


**Table 6. Awareness of the general types of climate information across gender (proportions)**

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Indigenous forecast** | 0.57 | 0.65 | -0.07** | 0.55 | 0.53 | 0.02 | 0.42 | 0.55 | -0.14*** | 0.12 | 0.13 | -0.01 | 0.34 | 0.35 | -0.01 |
| **Historical climate information** | 0.24 | 0.28 | -0.04 | 0.02 | 0.08 | -0.06*** | 0.08 | 0.17 | -0.09*** | 0.05 | 0.10 | -0.04** | 0.07 | 0.12 | -0.06** |
| **Short-term climate forecast** | 0.44 | 0.53 | -0.09** | 0.25 | 0.54 | -0.29*** | 0.16 | 0.23 | -0.07* | 0.14 | 0.28 | -0.14*** | 0.27 | 0.42 | -0.15*** |
| **Seasonal climate forecast** | 0.56 | 0.66 | -0.10*** | 0.43 | 0.67 | -0.24*** | 0.21 | 0.27 | -0.06 | 0.26 | 0.40 | -0.14*** | 0.25 | 0.38 | -0.13*** |
| n | 396 | 318 | | 161 | 144 | | 235 | 274 | | 410 | 398 | | 390 | 320 | |

* p<0.1, ** p<0.05, *** p<0.01

**Table 7. Differences between men and women for the main types of climate information received (proportions)**

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Indigenous forecast** | 0.76 | 0.77 | -0.01 | 0.47 | 0.43 | 0.04 | 0.84 | 0.75 | 0.09 | 0.82 | 0.75 | 0.07 | 0.89 | 0.86 | 0.03 |
| **Historical climate information** | 0.33 | 0.35 | -0.02 | 0.00 | 0.25 | -0.25 | 0.53 | 0.46 | 0.07 | 0.73 | 0.39 | 0.33** | 0.65 | 0.64 | 0.01 |
| **Short-term climate forecast** | 0.61 | 0.68 | -0.07 | 0.32 | 0.51 | -0.20 | 0.26 | 0.35 | -0.09 | 0.62 | 0.72 | -0.10 | 0.72 | 0.74 | -0.01 |
| **Seasonal climate forecast** | 0.72 | 0.80 | - 0.08* | 0.53 | 0.57 | -0.04 | 0.30 | 0.45 | -0.15 | 0.86 | 0.82 | 0.03 | 0.87 | 0.87 | 0.00 |
| n | 227 | 206 | | 89 | 77 | | 98 | 152 | | 49 | 51 | | 133 | 113 | |

* p<0.1, ** p<0.05, *** p<0.01

We further analyzed differences between men and women for the different types of climate information received among respondents who are aware of this information. There is no significant difference in climate information received across gender except for seasonal forecast in the Eastern Province and the historical climate information in the Southern Province (Table 7). Similarly the proportion of respondents who actually receive climate information is the highest for the indigenous forecasts and seasonal forecasts across provinces.

### Content of information received and lead times

Understanding the benchmark situation with respect to the content of the information communicated to the farm households is important to identify potential gaps and ways to address them. One of the objectives of the project is to improve the quality and diversity of information received by the project beneficiaries. Information content should be tailored to suit the needs of the surveyed households to ensure uptake. We asked the respondents about the content of the climate information that they received. A total of nine types of content were recorded for each type of climate information and responses are displayed in Figure 14.

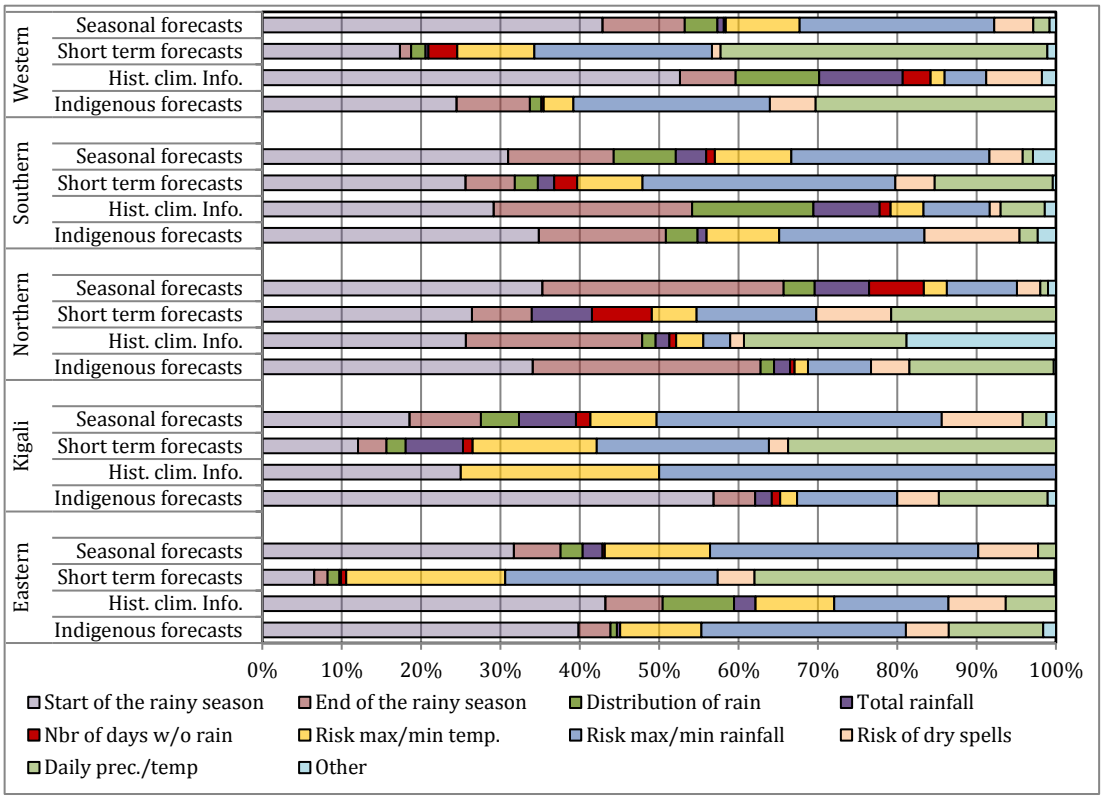
Overall the content of climate information reported by the respondents are the more traditional information usually communicated in the forecasts and other climate information. For example, in the seasonal forecast, the main types of content reported are by order of importance, start of the rainy season, risk of max/min rainfall or extreme events, end of rainy season, risk of max/min temperature. Start of the rainy season is the first main information communicated in the seasonal forecast in all provinces except Kigali and the Eastern Provinces where risk of max/min rainfall is ranked first. Other information such as risk of dry spells and distribution of the rain that can be of great use for farmers' decision making are reported but to a very small extent.

In the short-term forecast, daily precipitation and temperature is the most prominent information represented in the forecasts followed by the risk of maximum and minimum rainfall. Regarding the historical climate information, start of the rainy season and risk of maximum/minimum rainfall are the two most common contents communicated. But unlike the other types of climate information, distribution of rain throughout the season has a non-negligible presence in the historical climate information.

Start of the rainfall season is also clearly represented in the indigenous forecast, between 25% (in the Western Province) to 57% (in Kigali Province) of the cases relatively to the other types of content. Other prominent contents are the risk of maximum/minimum rainfall, daily precipitation and temperature and end of rainy season.

Improving the quality of climate information should therefore go beyond the conventional contents and emphasize on delivering to a greater extent information on distribution of rains, risk of dry spells that could further support farm operations and cropping activities.

**Figure 14. Content of the climate information received by the respondents**

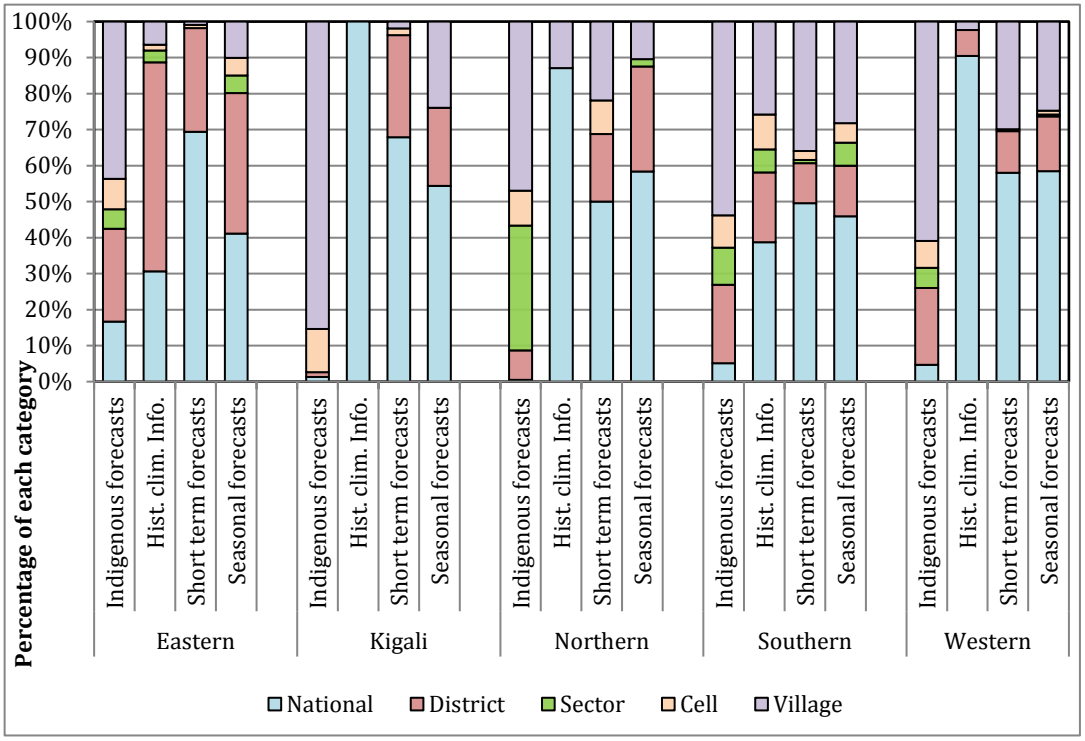



## Scale of provision of the information

The scale of provision of climate information matters to ensure that the information is place-specific and relevant for farmers' decision making. From Figure 15, it clearly appears that the indigenous climate forecast is the only climate information that is consistently provided at the village scale currently. This information may therefore be more relevant for farmers' decision making than those provided at a larger scale. At present, the other types of climate information namely, historical climate information, short-term and seasonal climate information are often provided either at the district or national scale. The project has therefore

a great role to play to ensure that the weather forecasts and other climate information are delivered at lower scales that can be useful and inform farmers' activities.

**Figure 15. Scale of provision of different types of climate information**




## Uncertainty

Farmer's expectation of uncertainty in the climate forecasts is key to understand potential barriers to uptake of climate information. Some authors argue that better use of climate information requires that users receive the information in probabilistic terms rather than deterministic formats (Visman et al. 2012). We captured farmers' expectation of uncertainty in the climate information received through a list of six statements describing a farmer's hypothetical decision making under uncertainty and perfect information. After reading the statement, each respondent is asked to report on the extent to which they behave like the farmer described.

Results for men and women are reported in Figure 16 and 17 respectively. For the same type of climate information, we compared their beliefs under situations of uncertainty and certainty. It is clearly apparent to a large extent for men and women interviewed in the Eastern and Kigali Provinces that seasonal forecasts are not deterministic predictions but convey some level of uncertainties and their farm decisions are often flexible to account for

these uncertainties. In the other districts, both men and women believe to a larger extent that the seasonal forecast convey more deterministic information. For the other types of climate information, results are more mitigated with no clear trend for men and women.

**Figure 16. Men's expectation of uncertainty in the climate information**

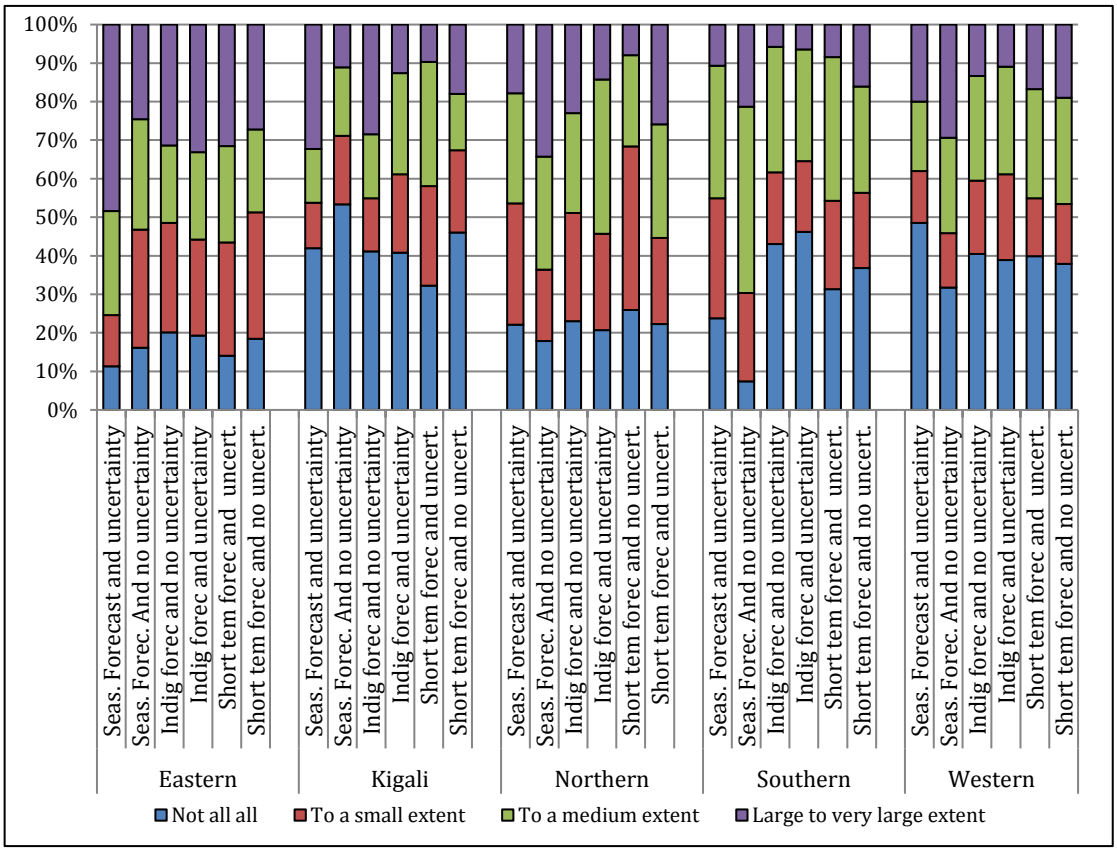
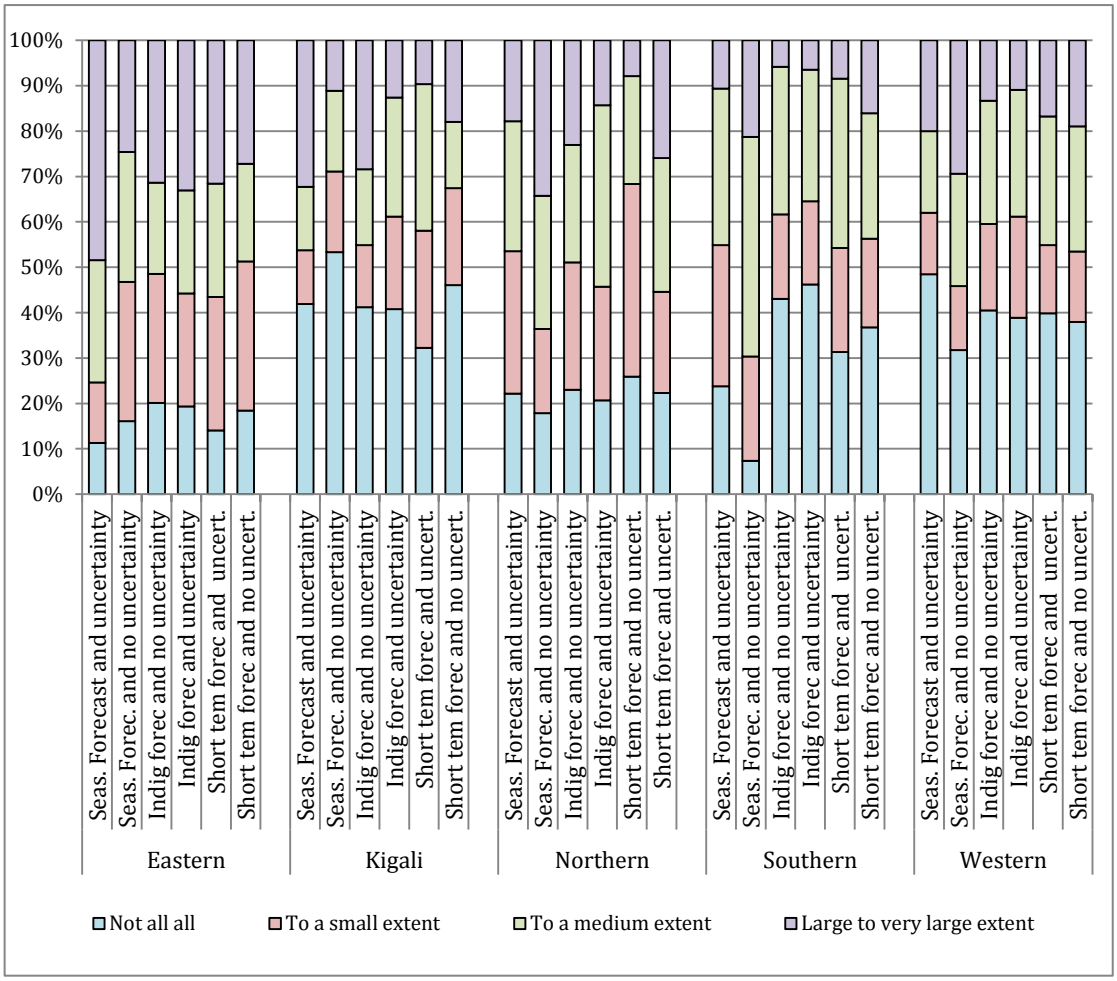


**Figure 17. Women's expectation of uncertainty in the climate information**




## Access to specific climate information

The main goal of the Rwanda Climate Services for Agriculture initiative is to improve access to specific climate information for better farm management decision making. After analyzing the general types of climate information respondents are aware of and receive, this section aims at assessing whether specific types of climate information products have reached both male and female respondents, the channels, and format used to communicate the information. It will also highlight the types of information actively sought by the respondents.

### Specific types of climate information received

Table 8 presents findings on respondents' access to specific types of climate information by gender. Overall, respondents have little access to climate information products, particularly in the province of Kigali surprisingly. Indeed, this province encompasses the capital city Kigali where the main office for the National Meteorological and Hydrological Service (NMHS) is

located. Therefore, we would expect respondents in this province to have better access to climate information than those located in other provinces. But this finding may be explained by the fact that agricultural households in this province are more involved in off farm activities (refer to Figure 3 above) leading to less opportunity to follow climate predictions. Respondents in the Eastern Province appear to be better off in terms of access to climate information products relative to those located in the other provinces. The most common information that respondents receive are the seasonal forecasts, the forecasts of onset of rainy season and the daily weather forecasts. Products such as early warnings and historical climate information barely reach respondents.

Generally men have significantly better access to the information than women in all provinces except the Northern Province. This may be because access to climate information products is associated to ownership of communication assets, group membership, social capital, and all these domains are where women fare behind men.

### Channels for receiving climate information

Further, respondents who receive climate information were asked about how they access each type of climate information among a list of 19 identified sources of diffusion of climate information. Since respondents' responses for the sources of access were similar across all types of climate information (for example radio is used to communicate climate forecasts, early warning or historical climate information), for more clarity in the presentation of the results, we decided to aggregate results by types of climate information for each source and province.

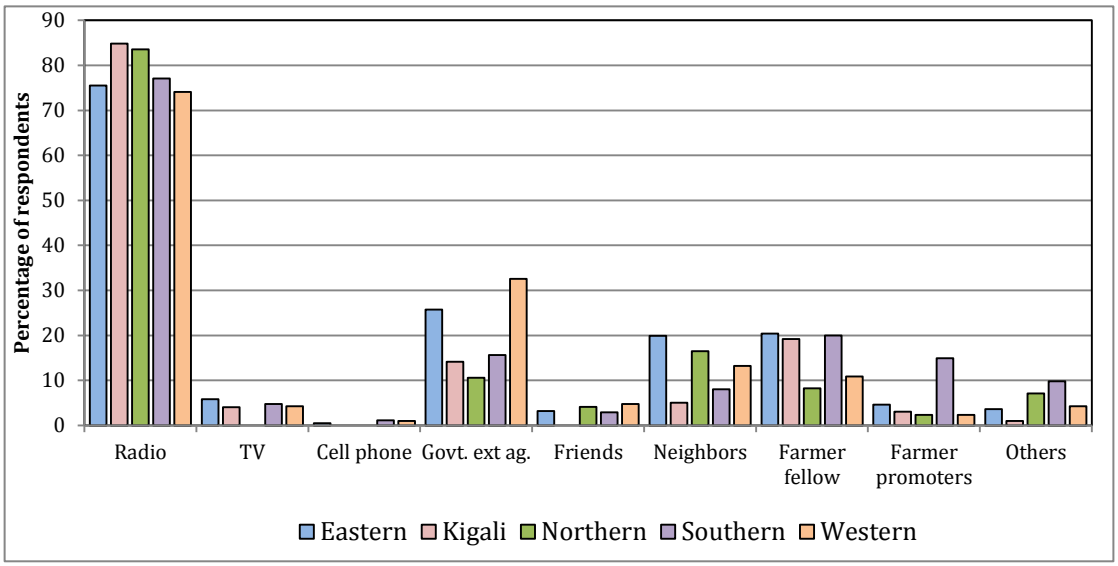
Table 8. Specific climate information received by respondents but this access is very variable across districts

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Forecasts** | | | | | | | | | | | | | | | |
| Extreme event | 0.15 | 0.24 | -0.09*** | 0.02 | 0.11 | -0.09**** | 0.09 | 0.14 | -0.05 | 0.12 | 0.20 | -0.08*** | 0.13 | 0.21 | -0.08*** |
| Onset of the rains | 0.30 | 0.38 | -0.08** | 0.04 | 0.14 | -0.1*** | 0.15 | 0.21 | -0.05 | 0.16 | 0.25 | -0.09*** | 0.16 | 0.26 | -0.10*** |
| Next 2-3 months | 0.32 | 0.38 | -0.06* | 0.20 | 0.28 | -0.09* | 0.16 | 0.22 | -0.05 | 0.16 | 0.27 | -0.11*** | 0.13 | 0.24 | -0.11*** |
| Next 2-3 days | 0.23 | 0.28 | -0.05 | 0.07 | 0.17 | -0.10*** | 0.09 | 0.14 | -0.05 | 0.05 | 0.09 | -0.03* | 0.09 | 0.18 | -0.08*** |
| Parasites/plant diseases | 0.07 | 0.09 | -0.01 | 0.02 | 0.06 | -0.04 | 0.05 | 0.05 | 0.00 | 0.06 | 0.10 | -0.04* | 0.06 | 0.11 | -0.04** |
| **Early warning** | | | | | | | | | | | | | | | |
| Flood | 0.00 | 0.01 | -0.01 | 0.00 | 0.02 | -0.02* | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | -0.01 | 0.02 | 0.03 | -0.01 |
| Drought | 0.20 | 0.26 | -0.05* | 0.03 | 0.07 | -0.04 | 0.09 | 0.05 | 0.03 | 0.09 | 0.09 | 0.00 | 0.06 | 0.12 | -0.06*** |
| Severe storm | 0.02 | 0.03 | -0.02* | 0.00 | 0.03 | -0.03 | 0.03 | 0.03 | 0.00 | 0.02 | 0.05 | -0.03** | 0.03 | 0.05 | -0.02* |
| **Historical climate information** | 0.05 | 0.02 | 0.03** | 0.00 | 0.00 | | 0.03 | 0.04 | -0.01 | 0.00 | 0.02 | -0.02** | 0.02 | 0.04 | -0.03** |
| **n** | **396** | **318** | | **161** | **144** | | **235** | **274** | | **410** | **398** | | **390** | **320** | |

* p<0.1, ** p<0.05, *** p<0.01.

Figure 18 displays the results of the main channels of communication for climate information received by the respondents by province. The other category includes channels that have not been used or barely used by the respondents. In the list of 19 potential channels provided, only four stood out clearly. These are radio, government extension agents, neighbors and fellow farmers. As expected, radio emerges by far as the principal source of dissemination of climate information consistently across provinces. Government extension agents ranked second, specifically in the Eastern and Western Provinces. Other social means of communication that rely on fellow farmers, neighbors, farmer promoter are non-negligible channels of communication. Despite being owned by a larger number of respondents than other communication assets, cell phone is rarely used to reach respondents with climate information. This implies that project emphasis on mobile-based climate information products has great potential to reach a very large audience and changes in access to these products could be easily detectable in follow-up surveys.

**Figure 18. Source of communication of climate information**




## Format of climate information received by farmers

As radio and government extension agents were the principal channels of dissemination of climate information, it is not surprising that the format supporting these channels reported by the respondents were audio and face to face group interaction, mostly in the Southern and Eastern Provinces or face to face individual interaction mainly in the Eastern, Northern and Kigali Provinces (Figure 19).

### Extent to which farmers are using the information

We next asked respondents who had access to climate information and the extent to which they were able to use the information. Ability to use the information refers to respondents' capacity to act on the information provided and often linked to respondents' endowments, farm assets, ability to understand the information and relevance of the information for them. Table 11 reports the results on respondents' ability to use the information by gender and province. Although we showed earlier a significant differential access to climate information across gender (Table 11), there are very few significant differences in the ability to use climate information among men and women within provinces but substantial differences across provinces. It appears also that the Western Province has the highest proportion of respondents (as high as 83%) who claimed to be able to use the climate information products while the Northern Province records the lowest proportions (as lows as 0%).

**Figure 19. Format for channeling climate information by province**

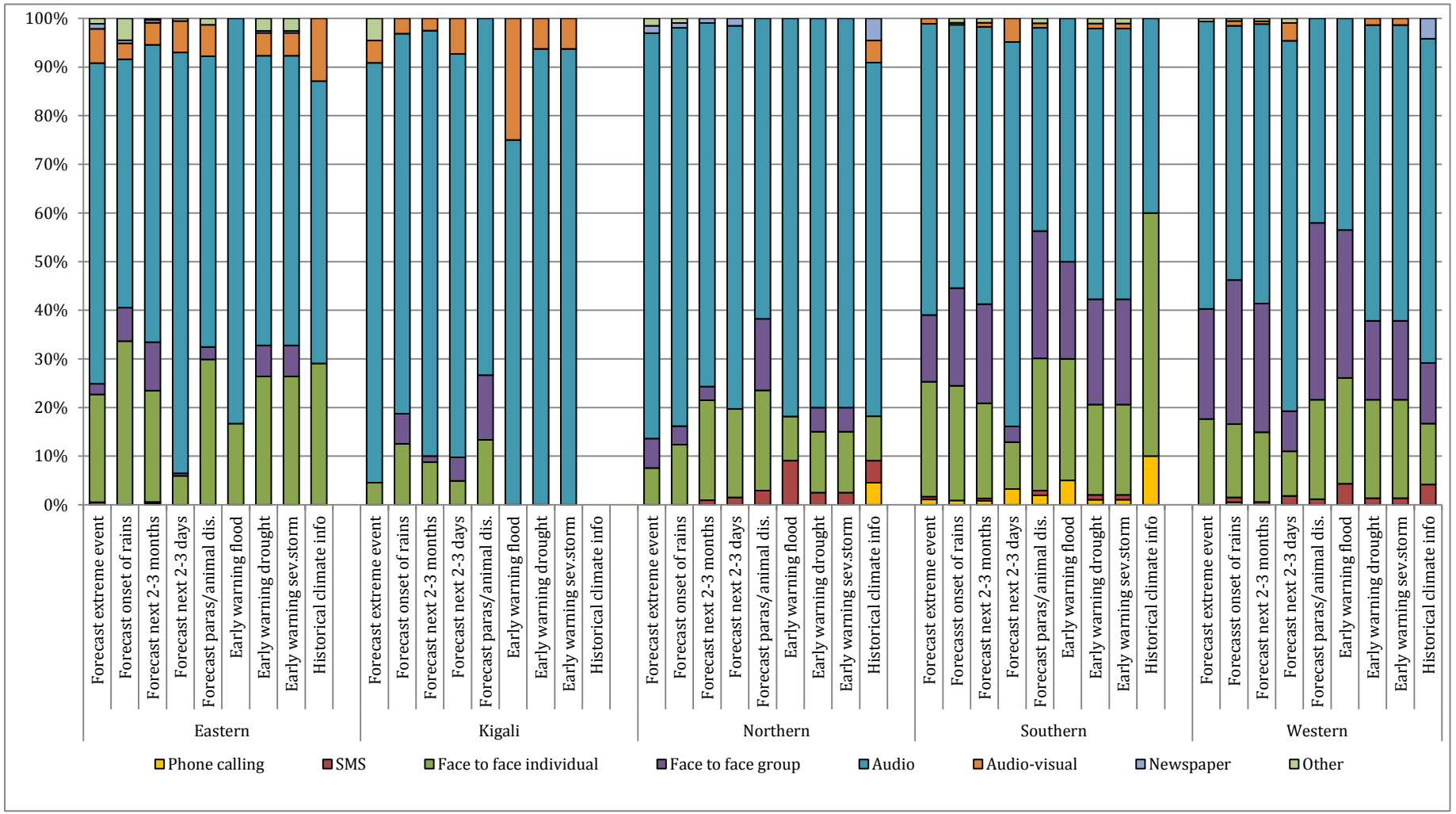
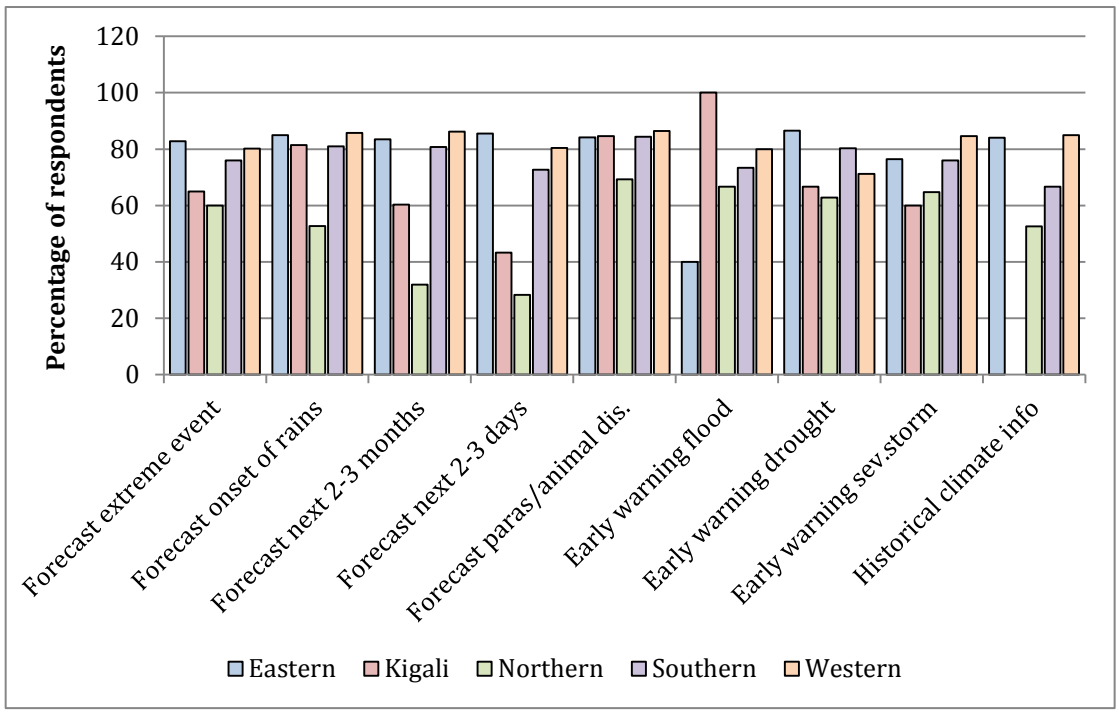


**Figure 20. Timeliness of climate information received**




## Information actively sought by farmers

In order to contribute to understanding the value that respondents place on climate information, we ask them whether they actively seek for the information regardless of whether they actually received it. Results presented in Table 10 reveal that very few respondents, less than one-third of the interviewees, actively seek for climate information. Early warning and historical climate information are the less sought information by the respondents. This may be because there is also less awareness and knowledge of these types of products. Differentiation of the results by gender shows that men seek more climate information regardless of the types of products than women and this is in all provinces surveyed. Possible explanations are, firstly, men are more aware of climate information as shown in Table 6, so have better understanding of how useful it can be for their crop activities. Secondly, they are the main decision makers concerning the inputs and agricultural investments for farming activities. They therefore are more likely to value more climate information to guide their agricultural investments.

### Use of climate information received by agro-ecology

Beyond the availability of climate information, end-users' ability to use it is of fundamental interest as this leads directly to intermediate impacts such as changes in behaviour, skills and practices that will help farmers to mitigate climate risk and to adjust to climate variability. In this section, we elicit respondents' perception of usefulness of climate information, the extent to which they are using the information and the constraints faced in using the information. We further focus on the advice received with the information and the ability of respondents to use the advice. Here, there is a clear differentiation between the mere fact of receiving raw information and receiving it with advice, which adds value to the information disseminated.

### Perception of usefulness of climate information received by farmers

Figure 21 illustrates respondents' perception regarding the usefulness of climate information received. Overall, those who received climate information found it to be useful or very useful, and this is to a greater extent in the Western, Southern and Eastern Provinces. Farmers' perception of the usefulness of climate information is an indication of the high value that they assign to the information and potential of this information to influence farm decisions. It is also good to understand what forecast attributes make the information useful to the respondents. Climate information may be considered useful because of several reasons: as a tool for decision making, when it unfolds as predicted, when disseminated by experts, and when it confirms traditional indicators observed.

### Timeliness of climate information received

Receiving the information on time, before the agricultural season, is also very critical for better planning of agricultural activities. We asked respondents whether the climate information received was on time to inform their agricultural and livelihood decisions. The vast majority of respondents claimed that the climate information products received were received on time to inform their agricultural and livelihood activities but the Northern Province appears to have the lowest percentages of positive responses (Figure 20). When comparing the difference in terms of timely access to climate information between men and women, there is no significant difference except for the Eastern Province, where a lower percentage of women reported receiving timely information (Table 9).

**Table 9. Gender differences in timely access to climate information across provinces (proportions)**

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Forecasts** | | | | | | | | | | | | | | | |
| Extreme event | 0.76 | 0.88 | -0.12* | 0.75 | 0.63 | 0.13 | 0.55 | 0.63 | -0.09 | 0.76 | 0.76 | -0.01 | 0.86 | 0.76 | 0.10 |
| | 59 | 75 | | 4 | 16 | | 22 | 38 | | 49 | 80 | | 49 | 67 | |
| Onset of rains | 0.78 | 0.92 | -0.14*** | 0.71 | 0.85 | -0.14 | 0.53 | 0.53 | 0.00 | 0.75 | 0.85 | -0.09 | 0.88 | 0.84 | 0.03 |
| | 119 | 120 | | 7 | 20 | | 36 | 57 | | 65 | 98 | | 64 | 83 | |
| Next 2-3 months | 0.81 | 0.86 | -0.05*** | 0.63 | 0.59 | 0.04 | 0.26 | 0.36 | -0.09 | 0.75 | 0.84 | -0.09 | 0.92 | 0.82 | 0.10* |
| | 127 | 122 | | 32 | 41 | | 38 | 59 | | 64 | 107 | | 52 | 78 | |
| Next 2-3 days | 0.87 | 0.84 | 0.03 | 0.25 | 0.52 | -0.27 | 0.23 | 0.32 | -0.09 | 0.67 | 0.76 | -0.10 | 0.89 | 0.75 | 0.14 |
| | 91 | 89 | | 12 | 25 | | 22 | 38 | | 21 | 34 | | 36 | 56 | |
| Parasites/animal diseases | 0.76 | 0.93 | -0.17* | 0.75 | 0.89 | -0.14 | 0.67 | 0.71 | -0.05 | 0.80 | 0.87 | -0.07 | 0.92 | 0.82 | 0.10 |
| | 29 | 28 | | 4 | 9 | | 12 | 14 | | 25 | 39 | | 25 | 34 | |
| **Early warnings** | | | | | | | | | | | | | | | |
| Flood | 0 | 0.5 | - | 0 | 1 | - | 0.6 | 0.75 | -0.15 | 0.67 | 0.78 | -0.11 | 0.83 | 0.78 | 0.06 |
| | 1 | 4 | | 0 | 3 | | 5 | 4 | | 6 | 9 | | 6 | 9 | |
| Drought | 0.83 | 0.90 | -0.08*** | 0.60 | 0.70 | -0.1 | 0.5 | 0.8 | -0.3 | 0.83 | 0.77 | 0.06 | 0.82 | 0.65 | 0.17 |
| | 81 | 82 | | 5 | 10 | | 20 | 15 | | 36 | 35 | | 22 | 37 | |
| Severe storm | 0.83 | 0.73 | 0.11 | 0.00 | 0.60 | - | 0.625 | 0.67 | -0.04 | 0.86 | 0.72 | 0.13 | 0.90 | 0.81 | 0.09 |
| | 6 | 11 | | 0 | 5 | | 8 | 9 | | 7 | 18 | | 10 | 16 | |
| **Historical climate information** | 0.84 | 0.83 | 0.01 | na | na | na | 0.63 | 0.45 | 0.17 | 1.00 | 0.63 | na | 1.00 | 0.78 | 0.21 |
| | 19 | 6 | | | | | 8 | 11 | | 1 | 8 | | 6 | 14 | |

* p<0.1, ** p<0.05, *** p<0.01. na: not applicable, did not receive the information; -: could not run the test because of small sample size

**Table 10. Information actively sought by respondents (proportions)**

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Forecasts** | | | | | | | | | | | | | | | |
| Extreme event | 0.21 | 0.31 | -0.1*** | 0.02 | 0.11 | -0.09*** | 0.20 | 0.23 | -0.03 | 0.08 | 0.19 | -0.11*** | 0.17 | 0.32 | -0.15*** |
| Onset of rains | 0.34 | 0.45 | -0.11*** | 0.03 | 0.13 | -0.10*** | 0.26 | 0.29 | -0.03 | 0.14 | 0.26 | -0.12*** | 0.20 | 0.35 | -0.15*** |
| Next 2-3 months | 0.29 | 0.37 | -0.08** | 0.04 | 0.15 | -0.11*** | 0.24 | 0.25 | -0.01 | 0.14 | 0.27 | -0.13*** | 0.19 | 0.35 | -0.16*** |
| Next 2-3 days | 0.23 | 0.32 | -0.08** | 0.03 | 0.12 | -0.09*** | 0.20 | 0.21 | -0.01 | 0.04 | 0.13 | -0.08*** | 0.13 | 0.26 | -0.13*** |
| Parasites/animal diseases | 0.20 | 0.25 | -0.05 | 0.02 | 0.12 | -0.09*** | 0.18 | 0.20 | -0.03 | 0.06 | 0.12 | -0.06*** | 0.15 | 0.27 | -0.13*** |
| **Early warnings** | | | | | | | | | | | | | | | |
| Flood | 0.16 | 0.23 | -0.06** | 0.02 | 0.11 | -0.09*** | 0.18 | 0.20 | -0.02 | 0.02 | 0.06 | -0.04*** | 0.08 | 0.16 | -0.08*** |
| Drought | 0.24 | 0.31 | -0.07** | 0.02 | 0.12 | -0.09*** | 0.21 | 0.21 | 0.00 | 0.05 | 0.12 | -0.07*** | 0.14 | 0.25 | -0.12*** |
| Severe storm | 0.18 | 0.23 | -0.05* | 0.02 | 0.11 | -0.09*** | 0.18 | 0.20 | -0.02 | 0.02 | 0.07 | -0.05*** | 0.09 | 0.18 | -0.09*** |
| Historical climate information | 0.14 | 0.19 | -0.05* | 0.02 | 0.10 | -0.09*** | 0.16 | 0.18 | -0.03 | 0.02 | 0.06 | -0.03*** | 0.08 | 0.15 | -0.07*** |
| **N** | **396** | **318** | | **161** | **144** | | **235** | **274** | | **410** | **398** | | **390** | **320** | |

* p<0.1, ** p<0.05, *** p<0.01

**Figure 21. Usefulness of the information received**

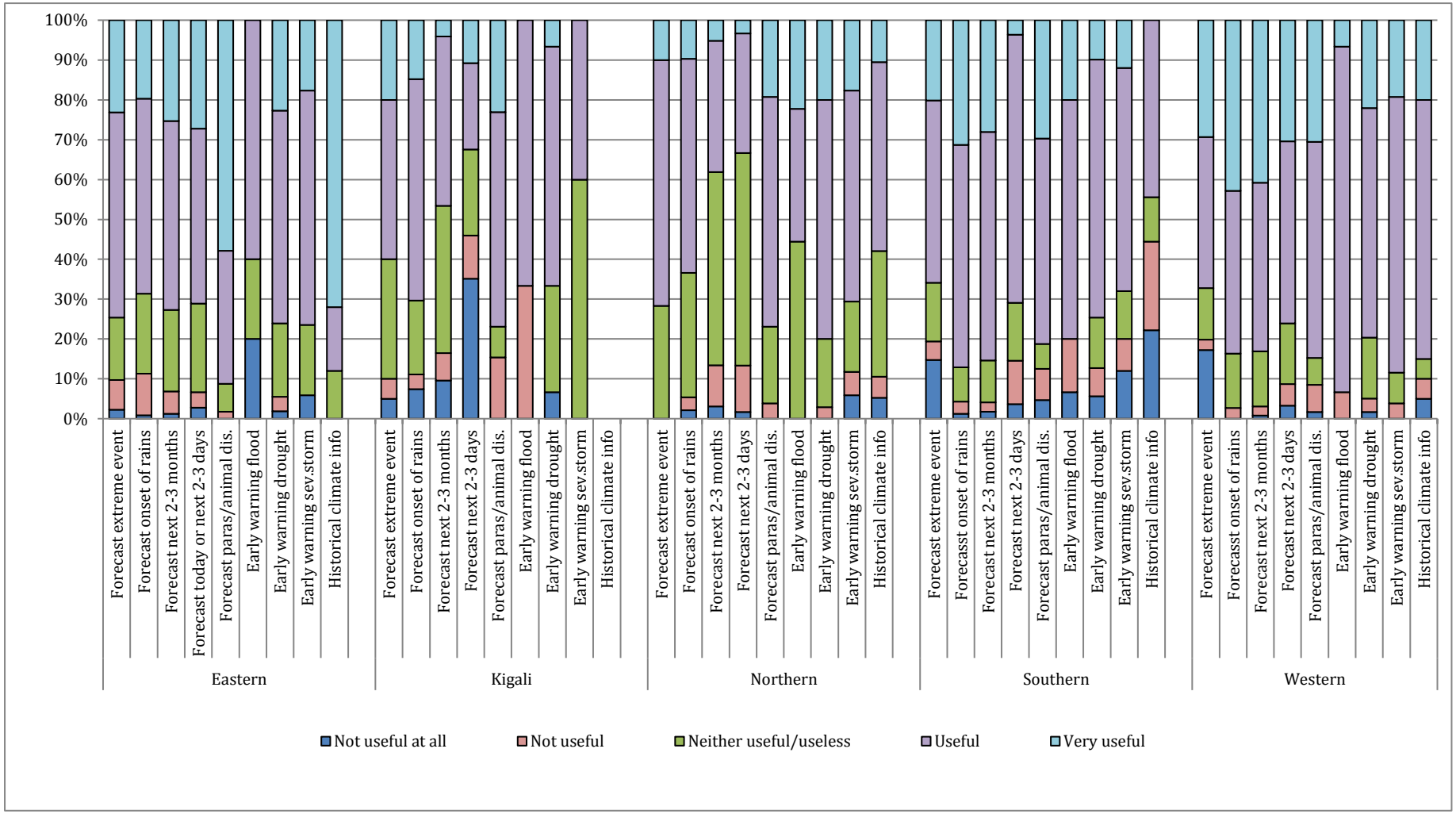


**Table 11. Gender differences in the ability to use climate information products (proportions)**

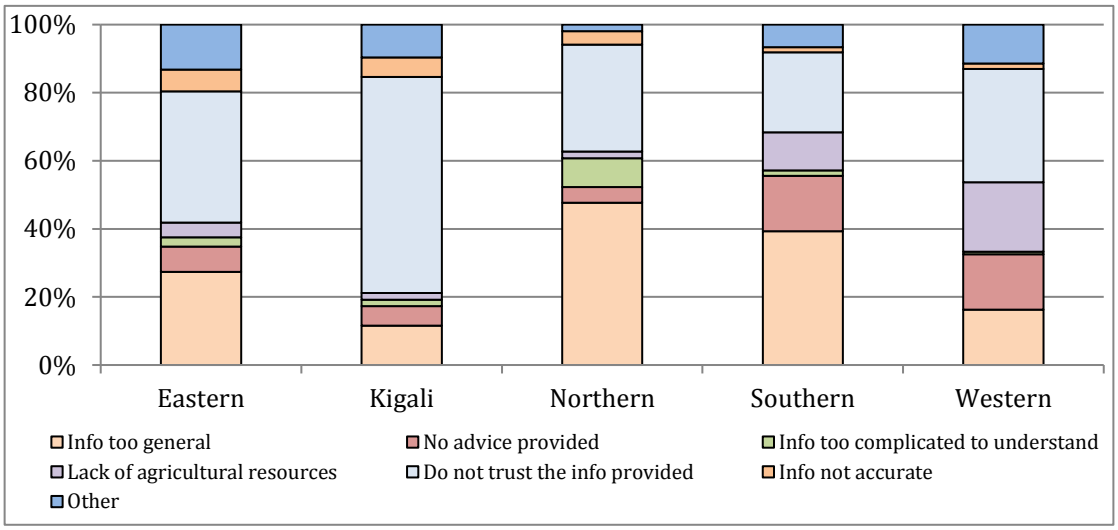
| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Forecasts** | | | | | | | | | | | | | | | |
| Extreme event | 0.55 | 0.49 | 0.06 | 0.25 | 0.43 | -0.18 | 0.18 | 0.34 | -0.16 | 0.32 | 0.38 | -0.06 | 0.54 | 0.50 | 0.04 |
| n | 53 | 68 | | 4 | 14 | | 22 | 38 | | 38 | 66 | | 41 | 52 | |
| Onset of rains | 0.41 | 0.48 | -0.08 | 0.67 | 0.61 | 0.06 | 0.27 | 0.38 | -0.11 | 0.53 | 0.49 | 0.04 | 0.57 | 0.60 | -0.03 |
| n | 106 | 106 | | 6 | 18 | | 33 | 55 | | 62 | 94 | | 63 | 80 | |
| Next 2-3 months | 0.39 | 0.40 | 0.00 | 0.43 | 0.34 | 0.09 | 0.00 | 0.25 | -0.25*** | 0.62 | 0.58 | 0.04 | 0.65 | 0.62 | 0.03 |
| n | 119 | 113 | | 23 | 38 | | 32 | 52 | | 61 | 103 | | 52 | 74 | |
| Daily/next 2-3 days | 0.44 | 0.44 | 0.00 | 0.33 | 0.18 | 0.16 | 0.00 | 0.13 | -0.13* | 0.35 | 0.23 | 0.12 | 0.60 | 0.37 | 0.23** |
| n | 86 | 82 | | | 17 | | 20 | 32 | | 17 | 30 | | 35 | 49 | |
| Parasites/animal diseases | 0.69 | 0.70 | -0.01 | 0.67 | 0.63 | 0.04 | 0.17 | 0.54 | -0.37* | 0.59 | 0.71 | -0.11 | 0.83 | 0.68 | 0.15 |
| n | 29 | 27 | | 3 | 8 | | 12 | 13 | | 22 | 34 | | 23 | 31 | |
| **Early warnings** | | | | | | | | | | | | | | | |
| Flood | 0.00 | 0.00 | - | 0 | 0.5 | - | 0.20 | 0.25 | -0.05 | 0.40 | 0.43 | -0.03 | 0.67 | 0.88 | -0.21 |
| n | 1 | 3 | | 0 | 2 | | 5 | 4 | | 5 | 7 | | 6 | 8 | |
| Drought | 0.46 | 0.39 | 0.07 | 0.75 | 0.40 | 0.35 | 0.21 | 0.60 | -0.39** | 0.44 | 0.47 | -0.03 | 0.45 | 0.26 | 0.19 |
| n | 78 | 76 | | 4 | 10 | | 19 | 15 | | 32 | 30 | | 22 | 34 | |
| Severe storm | 0.33 | 0.60 | -0.27 | 0.00 | 0.20 | - | 0.25 | 0.43 | -0.18 | 0.40 | 0.40 | 0.00 | 0.70 | 0.67 | 0.03 |
| n | 6 | 10 | | 0 | 5 | | 8 | 7 | | 5 | 15 | | 10 | 15 | |
| **Historical climate information** | 0.74 | 0.83 | -0.10 | 0.00 | 0.00 | na | 0.00 | 0.11 | -0.11 | 0.00 | 0.60 | na | 0.83 | 0.50 | 0.33 |
| n | 19 | 6 | | 0 | 0 | | 8 | 9 | | 0 | 5 | | 6 | 12 | |

* p<0.1, ** p<0.05, *** p<0.01; na: not applicable, did not receive the information; -: could not run the test because of small sample size

### Constraints in using the information received

In responding to the constraints that prevent them from using the climate information, to a large extent, most respondents identified the non-relevance of the information provided at a large scale (information too general) and the lack of trust in the information communicated (Figure 22).

**Figure 22. Constraints in using climate information**




### Extent to which farmers are applying the advice received

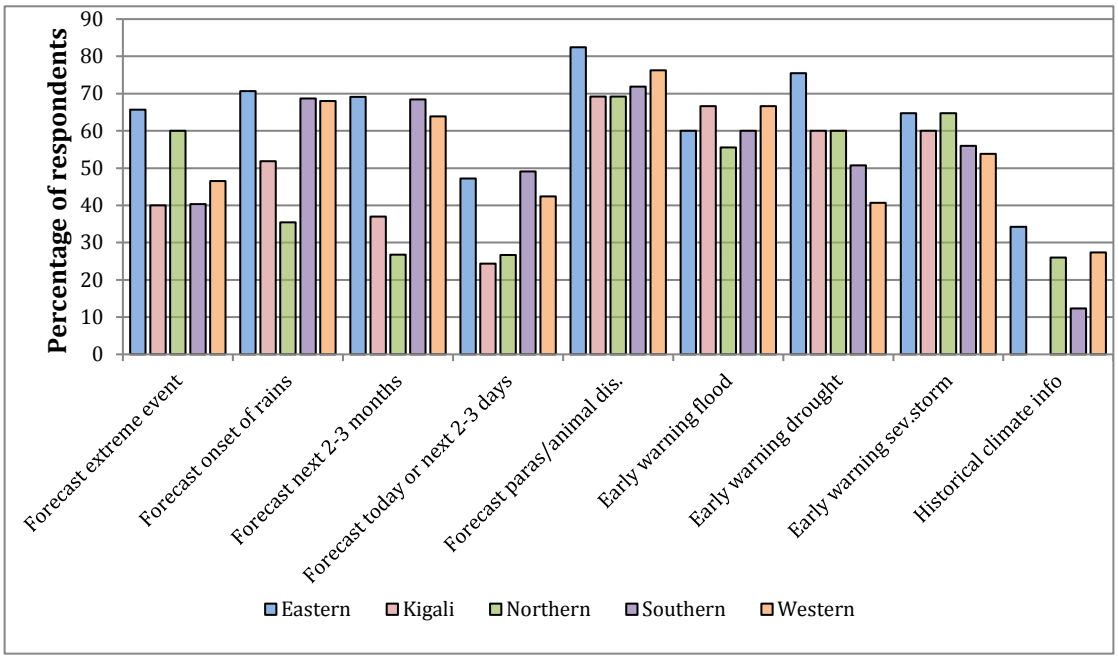
We further asked respondents whether the information communicated comes with advice on how to use it. From Figure 23, it appears that respondents report consistently across provinces that the main information delivered with advice are by order of importance the forecast for parasites, plant/animal diseases and early warnings. The daily weather forecasts and the historical climate information are the information that comes currently with least advice. The advice received varies according to the type of climate information received (Figure 24). But generally, advice related to the planting of early maturing varieties, early land preparation, introduction of new crop varieties and early planting are the most dominant advice provided, consistently across province.

### Ability to use the advice by gender and province

Table 12 presents the results of respondents' ability to use the advice provided with the climate information. The pattern observed in the responses reported in the table is almost similar to that of Table 11 related to the ability to use climate information. The Northern

Province comes last, in the ability to use the advice while the Southern Province comes first. Very few significant differences exist across gender in the ability to use the advice.

**Figure 23. Climate information with advice**




## Educational radio programs and training on climate information

Educational radio programs and training on climate information offer important support to disseminate climate information. They create a space for interaction where end-users, intermediary extension agents, researchers, climate information producers can exchange information, share concepts and thereby build end-users' knowledge and capacity to use climate information.

### Access to educational radio programs

We disaggregated access to radio educational programs by gender and province (see Figure 25). Overall less than half of the respondents interviewed have access to radio educational programs. Proportions of men who have access to such programs vary from a lowest of 31% in the Northern Province to a highest of 53% in the Eastern Province. For women, proportions are between 26% in Kigali and 31% in the Eastern Province. These proportions of men and women in all provinces are significantly different.

**Figure 24. Advice received on the climate information provided by province**

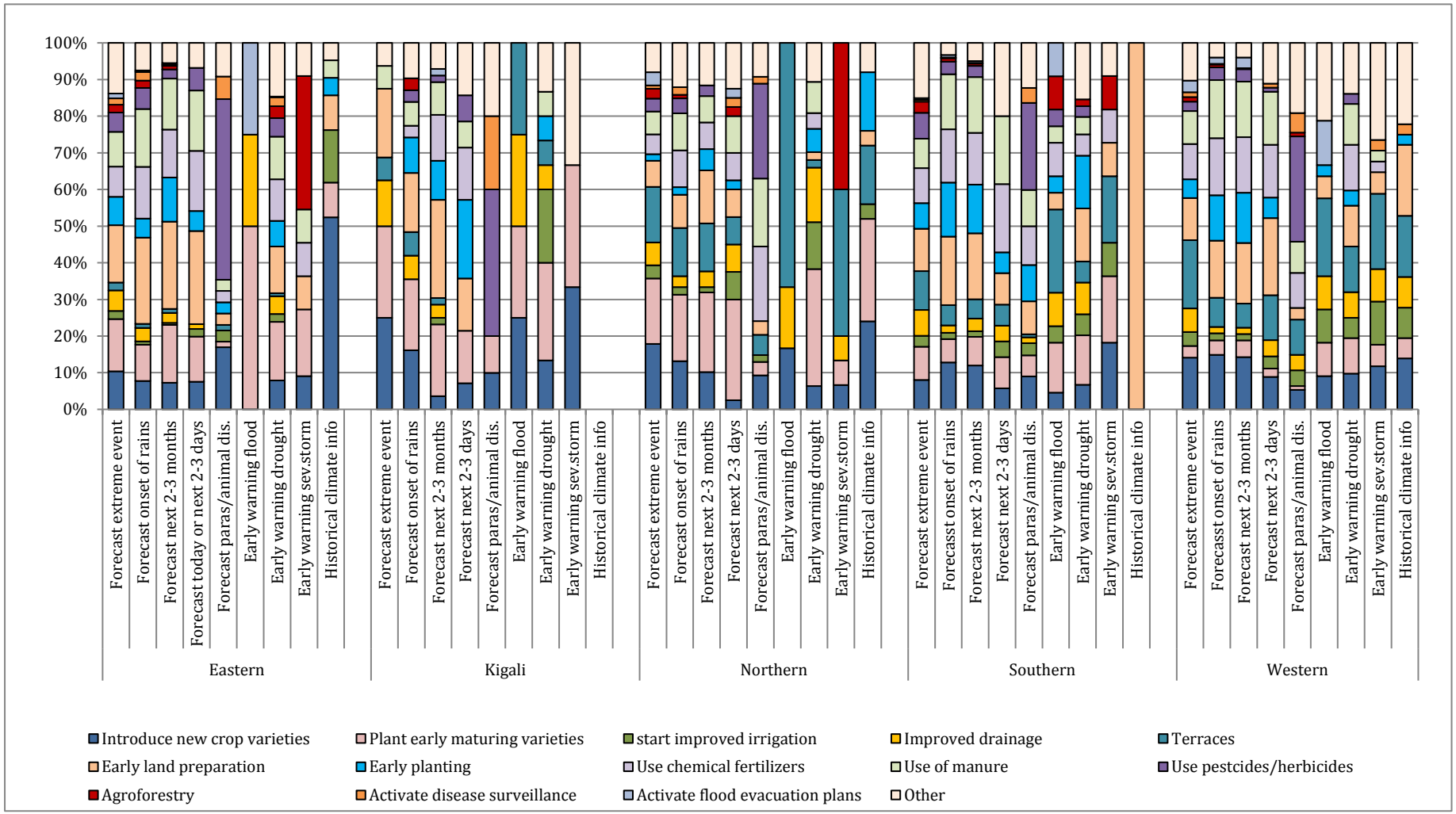


**Table 12. Ability to use the advice by gender (proportions)**

| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| **Forecasts** | | | | | | | | | | | | | | | |
| Extreme event | 0.53 | 0.63 | -0.10 | 1.00 | 0.50 | 0.50 | 0.08 | 0.38 | -0.29* | 0.50 | 0.35 | 0.15 | 0.48 | 0.52 | -0.04 |
| n | 40 | 48 | | 2 | 6 | | 12 | 24 | | 18 | 34 | | 21 | 33 | |
| Onset of rains | 0.39 | 0.46 | -0.08 | 0.75 | 0.60 | 0.15 | 0.07 | 0.42 | -0.35** | 0.61 | 0.50 | 0.11 | 0.59 | 0.76 | -0.18* |
| n | 85 | 84 | | 4 | 10 | | 14 | 19 | | 44 | 68 | | 41 | 59 | |
| Next 2-3 months | 0.41 | 0.45 | -0.04 | 0.40 | 0.41 | -0.01 | 0.11 | 0.29 | -0.18 | 0.65 | 0.59 | 0.06 | 0.66 | 0.80 | -0.15 |
| n | 92 | 80 | | 10 | 17 | | 9 | 17 | | 43 | 74 | | 32 | 51 | |
| Daily | 0.51 | 0.50 | 0.01 | 0.33 | 0.33 | 0.00 | 0.00 | 0.30 | -0.30 | 0.44 | 0.22 | 0.22 | 0.36 | 0.60 | -0.2 |
| n | 43 | 42 | | 3 | 6 | | 6 | 10 | | 9 | 18 | | 14 | 25 | |
| Parasites/animal diseases | 0.65 | 0.67 | -0.01 | 0.33 | 0.5 | -0.15 | 0.22 | 0.56 | -0.33 | 0.73 | 0.68 | 0.06 | 0.69 | 0.66 | 0.03 |
| n | 23 | 24 | | 3 | 6 | | 9 | 9 | | 15 | 31 | | 16 | 29 | |
| **Early warnings** | | | | | | | | | | | | | | | |
| Flood | 0.00 | 0.00 | na | 0 | 0.5 | - | 0 | 0.50 | -0.50 | 0.75 | 0.40 | 0.35 | 0.36 | 0.54 | -0.17 |
| n | 0 | 3 | | 0 | 2 | | 3 | 2 | | 4 | 5 | | 11 | 13 | |
| Drought | 0.42 | 0.48 | -0.06 | 0.67 | 0.50 | 0.17 | 0.10 | 0.45 | -0.35* | 0.63 | 0.30 | 0.35* | 0.68 | 0.66 | 0.03 |
| n | 62 | 61 | | 3 | 6 | | 10 | 11 | | 16 | 20 | | 16 | 29 | |
| Severe storm | 0.50 | 0.44 | 0.06 | 0.00 | 0.33 | - | 0.17 | 0.40 | -0.23 | 0.33 | 0.36 | -0.03 | 0.60 | 0.89 | -0.29 |
| n | 2 | 9 | | 0 | 3 | | 6 | 5 | | 3 | 11 | | 5 | 9 | |
| **Historical climate information** | 0.83 | 1.00 | -0.17 | na | na | na | 0.00 | 0.33 | -0.33 | 0.00 | 0.33 | na | 0.80 | 0.57 | 0.23 |
| **n** | 12 | 5 | | | | | 5 | 6 | | 0 | 3 | | 5 | 7 | |

* p<0.1, ** p<0.05, *** p<0.01; na: not applicable, did not receive the information; -: could not run the test because of small sample size

These educational radio programs have been mostly useful to inform crop decisions. Majority of respondents reported that they changed some of their crop decisions after listening to these programs (see Figure 26). Livestock and livelihood decisions have been less informed by these programs, probably because information provided during these programs were more related to crop decisions than to other livelihood activities.

**Figure 25. Access to radio educational programs**

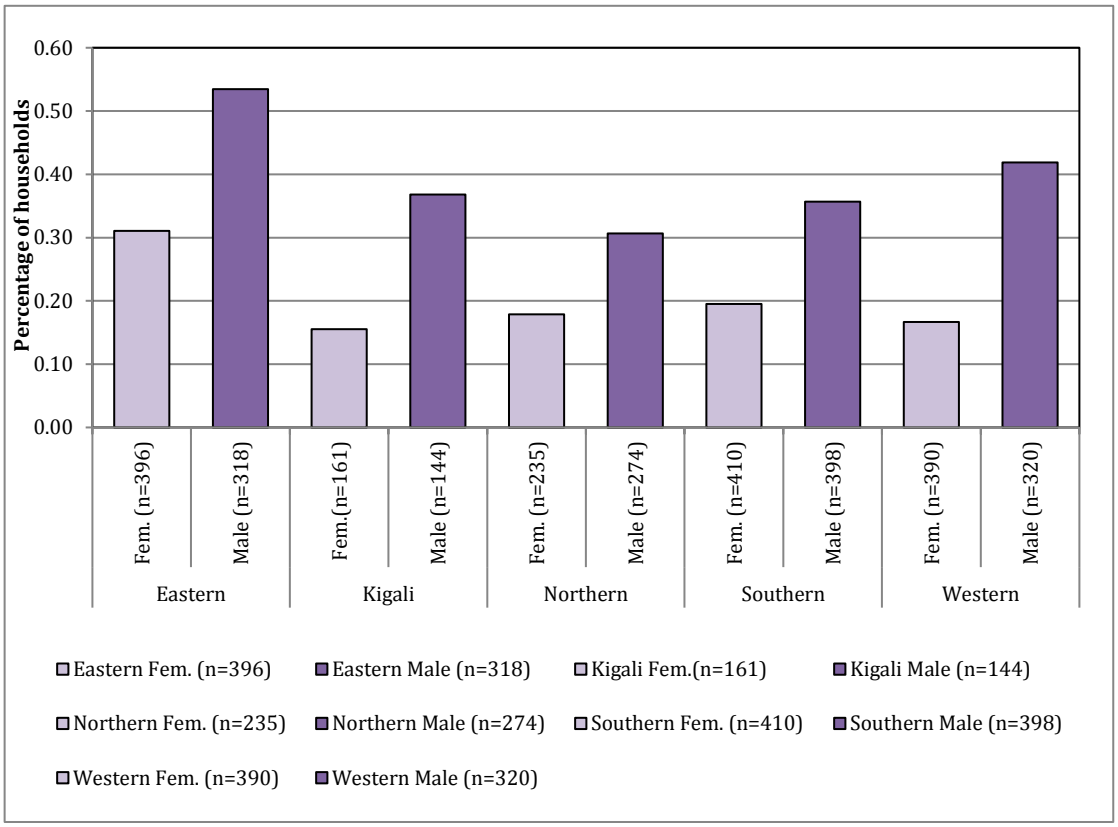
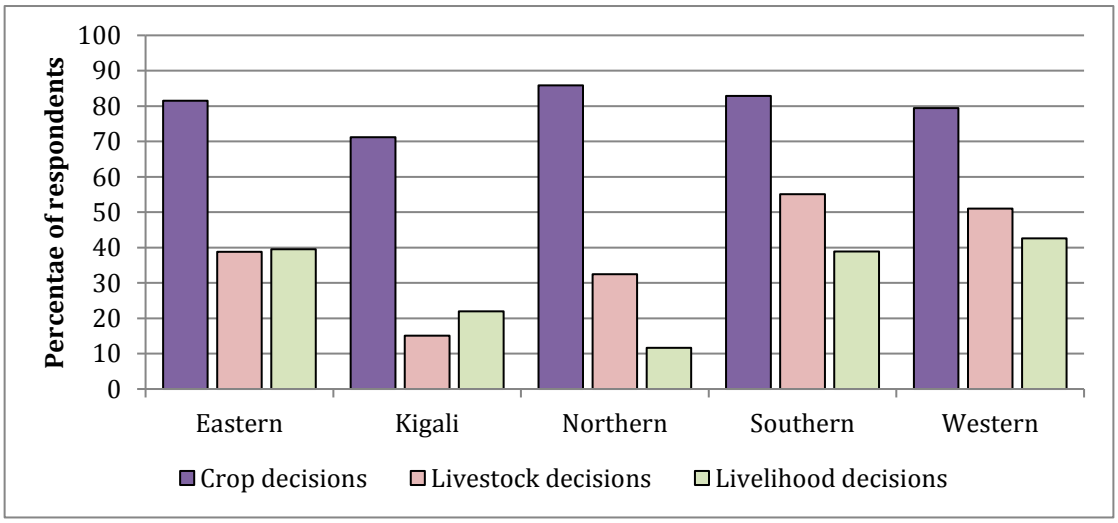



**Figure 26. Changes in farm decisions as a result of access to radio educational programs**



### Access to training on climate information

One of the main emphases of the project is to ensure effective access and use of climate information by conducting participatory workshops where farmers are trained to understand the probabilistic climate forecasts, historical climate information and other early warnings and how they can use the information in their crop/livestock and livelihood decision making. The training approach used is the Participatory Integrated Climate Services in Agriculture (PICSA) led by the University of Reading. So, to capture information on the PICSA training and the resulting effect on farmers' livelihoods, respondents were asked a series of questions on training on climate information.

Results reported in Table 13 show clearly that almost no respondent interviewed has ever attended a training on climate information. These results confirm that the households interviewed have not yet benefited from the project training program and can thus represent a solid baseline against which future change as the result of the project training program will be evaluated. These findings also suggest that there is good opportunity to impact households' livelihoods with the training programs.

**Table 13. Respondents that attended trainings on climate information (percent)**

| | Training attended | | Number sampled | |
|---|---|---|---|---|
| **Region** | **Female** | **Male** | **Female** | **Male** |
| **Eastern** | 1% | 0% | 396 | 318 |
| **Kigali** | 0% | 0% | 161 | 144 |
| **Northern** | 0% | 0% | 235 | 274 |
| **Southern** | 0% | 0% | 410 | 398 |
| **Western** | 0% | 0% | 390 | 320 |

Though they have never attended a training on climate information, the large majority of respondents (more than 80%) reported that they will be interested to attend a training on climate information. Since respondents have not received yet training on climate information, the usefulness of these trainings and the resulting change in decision making could not be analyzed.

### Satisfaction with climate information received

We asked also respondents whether they were satisfied with the types of climate information they were currently receiving. Answers were mitigated with almost half of the respondents

not being satisfied with the current climate information received (Figure 27). An overwhelming majority of respondents (more than 80%) claimed also that their access to climate information has decreased or stayed the same over the past year (results not reported). Women are the least satisfied with the information received with a statistical difference across gender in the Eastern, Kigali and Western Province. This is likely because the information currently provided meets women's needs to a lesser extent. It is therefore important for the project to understand women's needs and how information could be better tailored to suit these needs.

Respondents who were not satisfied would like to receive information mostly with advice, the distribution of rains over the season, end of the rainy season and the risk of having maximum/minimum rains and other (Figure 28) such as information on climate change, disaster risk management, and general agronomic advice (more efficient use of fertilizer, improved seeds, drought-tolerant crops).

**Figure 27. Satisfaction by gender with the climate information received**

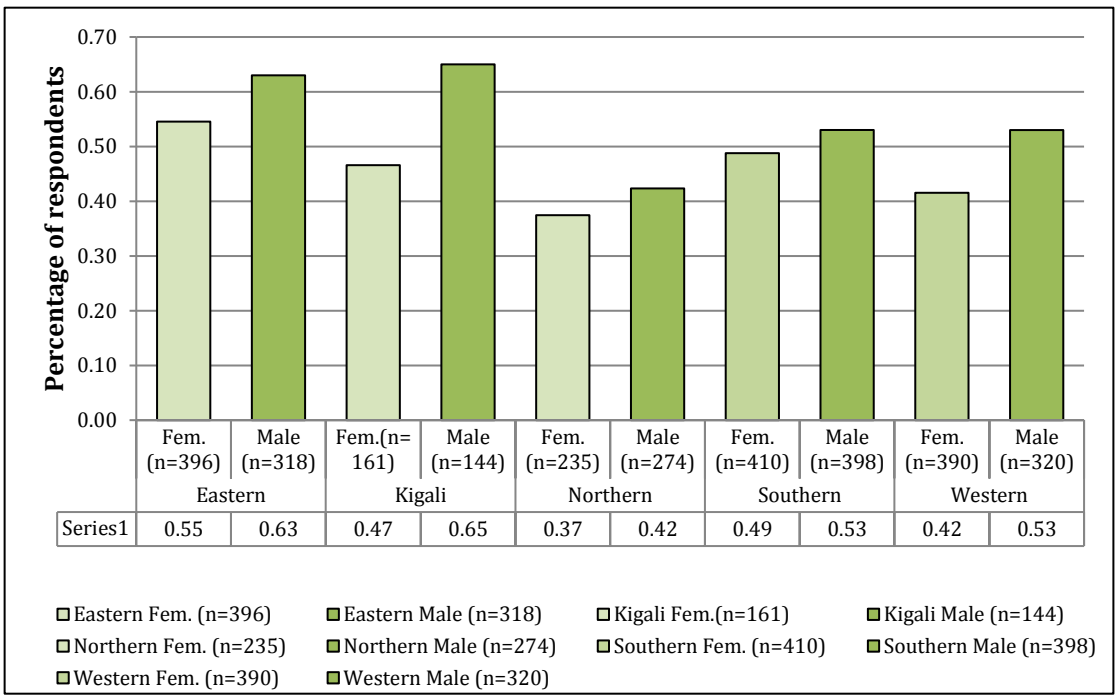
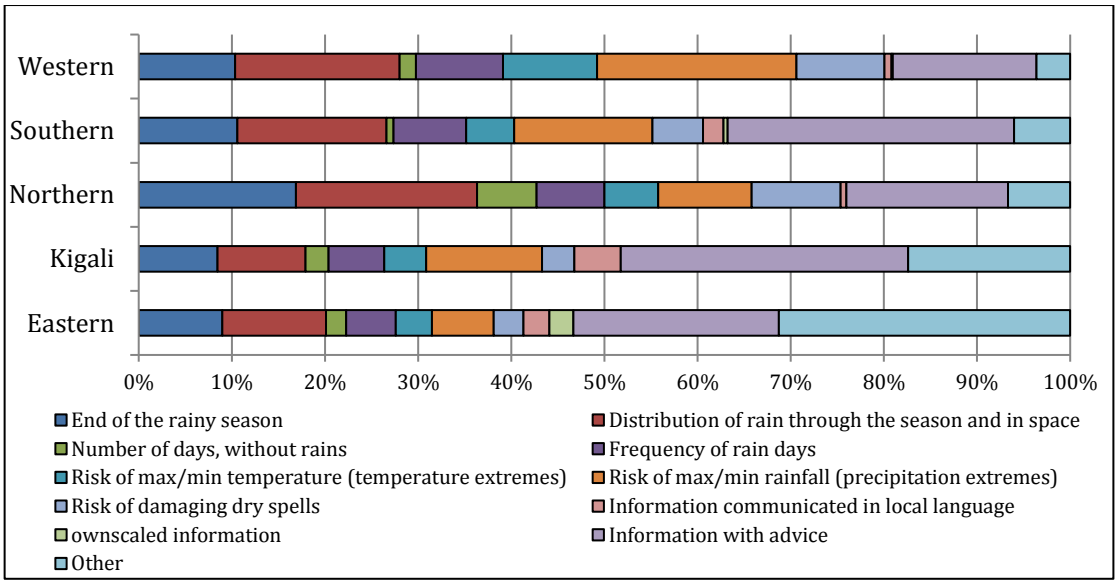


**Figure 28. Improvement would like to see in the climate information provided**



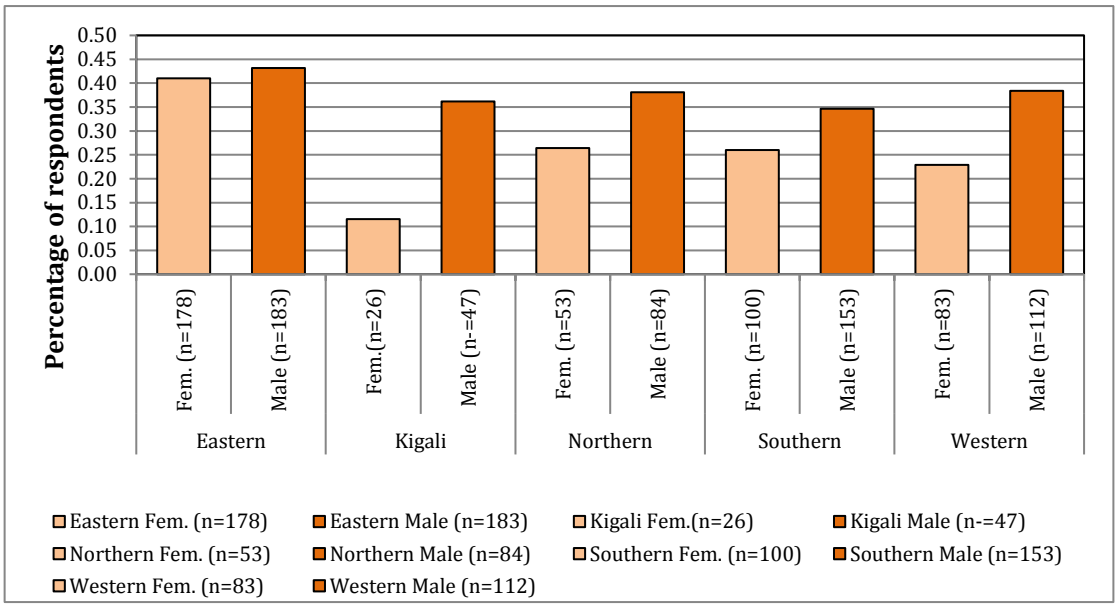

## Behavioral changes, perceived benefits and impact from climate information

Greater access and use of climate information are expected to translate into some behavioral changes and livelihood benefits for the community of farmers. Since it may be difficult to fully quantify behavioral change and derive a causal relationship with livelihood improvement, we assessed qualitatively these indicators using Likert-type questions.

### Behavioral changes

We first asked respondents whether they perceive any change in their livelihood activities after using the climate information. Farmers 'responses are represented in Figure 29 disaggregated by gender. Less than 45% of the respondents acknowledge that their use of climate information has resulted in changes in their livelihood with a significant difference between men and women in Kigali Province (36% for men against 12% for women) and the Western Province (23% for women against 38% for men).

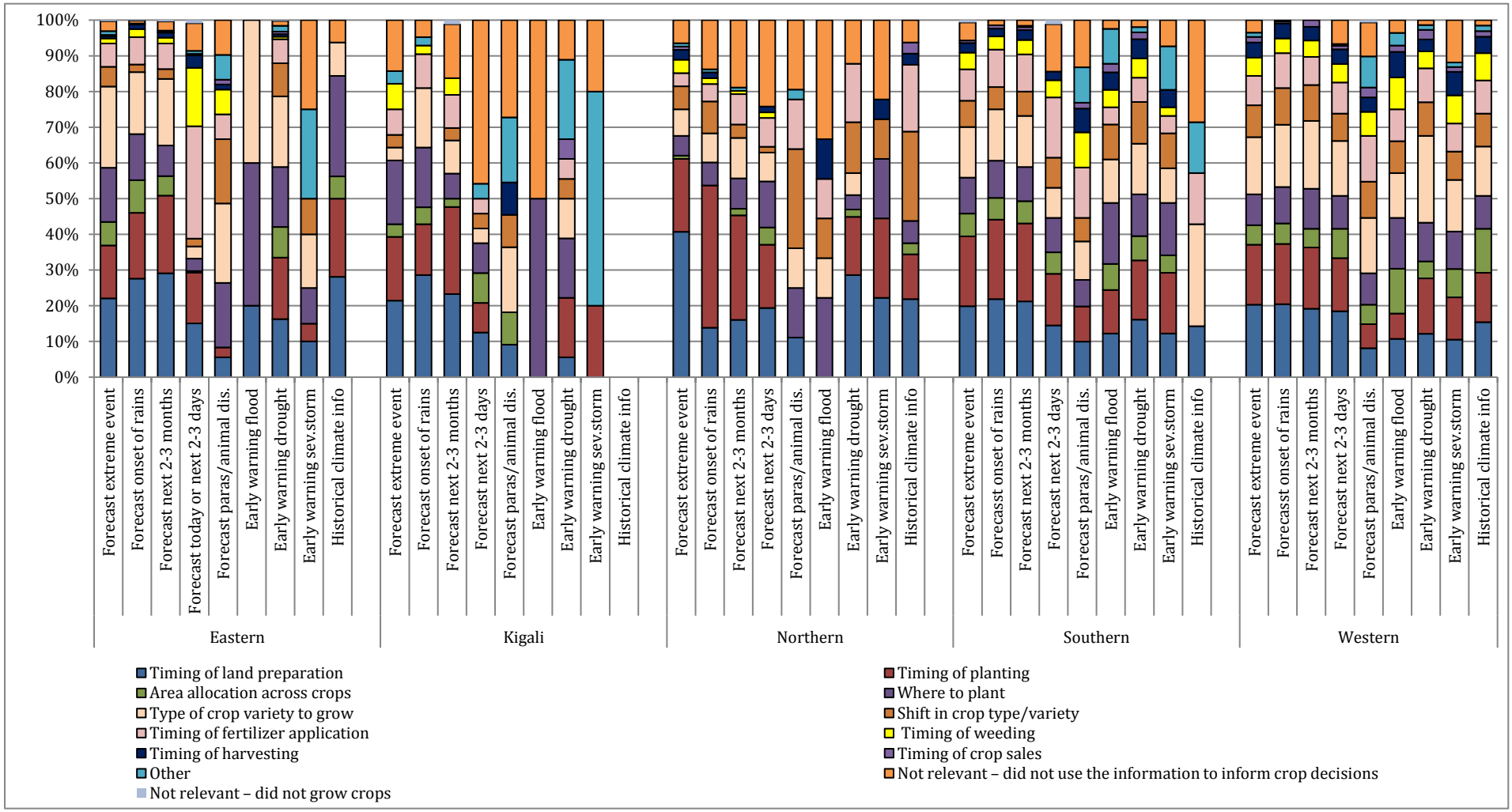
**Figure 29. Effect perceived after using the climate information by gender and province**




## Changes in farm management decisions

The main goal sought by the project in providing access and enhancing use of climateservices is to help farmers and agro-pastoralists to improve their farm management in response to the information received. In order to track any improvement in farm management as a result of access and use of climate information, we asked farmers about the types of farm decisions that were informed by the climate information currently received. Farmers' responses are reported in Figure 30. It appears that a good percentage of farmers use climate information to inform their farm decisions, mainly in the Eastern, Southern and Western Provinces. Climate information in general but to a greater extent climate forecasts are mostly used to inform decisions on land preparation, timing of planting and the types of crop varieties to grow, consistently across provinces.

**Figure 30. Farm management decisions informed by climate information received**



### Changes in behavior

A main outcome pursued by the project is to influence behavior, knowledge, attitude, skills and practices following increased use of climate services. Given the relatively short period of project implementation, these types of outcomes will be sought by the project and assessed during the project life time rather than any long term impacts. We assessed baseline indicators of behavioral changes through qualitative statements. A list of statements describing improved knowledge, attitude, behavior, practices/skills as a result of greater use of climate information were read to farmers and their level of agreement with each statement was sought using a Likert scale. For the sake of clarity in presenting the results, we report results in Table 14 below for those who strongly disagree (SD) or disagree (D) with each statement.

The large majority of farmers disagree or strongly disagree that the climate information received has translated in any changes with regard to crop, livestock management or other livelihood activities. But there is lesser disagreement about some changes in practices related to keeping new livestock breeds and diversification into new business activity. These results are expected since this is a before project, baseline situation. We would expect behavioral changes to occur in the next years following the project interventions. It is also interesting to note that in Figure 30, a good percentage of farmers reported to use climate forecasts for land preparation and planting in the past agricultural season in 2015. But in this table, there is high percentage of farmers (at least 70%) who disagree with the statement "I am able to use climate information to support my decisions regarding crop management."This result may imply that using climate forecast during one agricultural season does not systematically translate in improved ability to use climate information. This latter is more of a process, constant exposure, attributes of the services that facilitate uptake, understanding and effective change in behaviour. As farmers identified trust in the information as one of the main constraint limiting the use of the information, it also implies that constant interaction with quality climate forecasts will build trust and likely translate into observable behavioral changes.

**Table 14. Changes in behavior (percent)**

| | Eastern | | Kigali | | Northern | | Southern | | Western | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SD | D | SD | D | SD | D | SD | D | SD | D |
| *Change in attitude* | | | | | | | | | | |
| **I am able to choose crop types/variety that are suited to the local climate and circumstances** | 8.55 | 86.84 | 20.00 | 60.00 | 15.22 | 76.09 | 8.86 | 84.81 | 37.10 | 61.29 |
| **I am able to choose livestock types adapted to the local climate and circumstances** | 8.42 | 69.47 | 6.25 | 25.00 | 8.57 | 60.00 | 6.15 | 69.23 | 26.09 | 54.35 |
| **I am able to use climate information to support my decisions regarding crop management** | 7.24 | 85.53 | 21.05 | 57.89 | 13.04 | 73.91 | 6.33 | 83.54 | 24.19 | 69.35 |
| **I am willing to pay for climate forecasts** | 3.95 | 38.82 | 0.00 | 55.00 | 2.22 | 44.44 | 2.53 | 32.91 | 12.90 | 43.55 |
| *Change in knowledge/awareness* | | | | | | | | | | |
| **I understand climate forecasts and I am able to use the information to support my decisions regarding livestock management** | 7.62 | 65.71 | 0.00 | 25.00 | 10.00 | 52.50 | 4.48 | 70.15 | 22.00 | 50.00 |
| **I have a good mastery of the rainfall starting date and how the rainfall season will behave** | 4.61 | 48.03 | 10.00 | 50.00 | 4.44 | 71.11 | 3.80 | 59.49 | 16.13 | 48.39 |
| **I am becoming more aware of climate variability/change** | 6.58 | 57.89 | 15.00 | 15.00 | 2.22 | 60.00 | 3.80 | 63.29 | 11.29 | 41.94 |
| **I know the opportunities and risk of taking a bank/microfinance loan** | 5.37 | 44.30 | 20.00 | 25.00 | 9.52 | 47.62 | 5.33 | 29.33 | 19.35 | 50.00 |
| **I know the opportunities and risk of starting new business** | 8.72 | 55.70 | 15.00 | 25.00 | 4.65 | 65.12 | 5.33 | 34.67 | 16.13 | 48.39 |
| *Change in practice* | | | | | | | | | | |
| **I have started to plant a new crop based on the information and advice received** | 7.89 | 65.79 | 10.00 | 60.00 | 8.70 | 52.17 | 7.59 | 58.23 | 22.58 | 56.45 |
| **I have started to keep new livestock breeds** | 5.21 | 39.58 | 0.00 | 11.76 | 2.94 | 29.41 | 3.13 | 31.25 | 18.18 | 27.27 |
| **I am using more soil and water conservation practices (agroforestry, composting, zai pits, stone bunds, etc)** | 6.58 | 57.24 | 5.00 | 40.00 | 4.65 | 55.81 | 5.06 | 64.56 | 14.52 | 59.68 |
| **I am using more purchased inputs (fertilizer, improved seeds) for my crop production** | 8.55 | 75.00 | 21.05 | 42.11 | 4.55 | 81.82 | 10.13 | 73.42 | 35.48 | 53.23 |
| **I am using more improved crop varieties** | 7.24 | 81.58 | 15.79 | 42.37 | 11.36 | 68.18 | 10.13 | 78.48 | 29.03 | 53.23 |
| **I have started a new business activity** | 5.59 | 24.48 | 5.56 | 11.11 | 0.00 | 10.00 | 2.67 | 16.00 | 13.11 | 22.95 |

### Perceived impact

Changes in behavior resulting from greater uptake of climate information are likely to translate in livelihood impacts in the medium or long term. Because of a number of factors that can also impact crop yields, livestock outputs and other livelihoods, it is challenging to fully attribute in a reliable way the observed livelihood changes due to the climate information received without using more elaborated quantitative approaches. For this reason and in this baseline report, we adopted a qualitative method (although quantitative data has been collected and could be used for quantitative assessment if the need emerges) to assess baseline indicators of impact. A list of qualitative/Likert-type statements related to farmers' perception of the impact of climate information on their livelihood activities was read to the respondents and they were asked about their agreement with each statement. The impacts investigated are in terms of improved livelihood, crop/livestock portfolio, income and livelihood. The main perceived impact reported by the respondents is related to stability of their crop outputs and income in bad years. Climate information is currently useful to the respondents to lessen fluctuation in food security and income, particularly during bad rainfall years.

It is noteworthy to see that the changes in timing of land preparation, planting, choices of crops/livestock breeds were part of farmers' risk management strategies to reduce variability in income. Farmers' objectives are not solely to maximize yields or income but also to reduce variability in their yields and income. This is why the mere focus on increase in mean crop yield to assess impact of climate information may be limited to capture the effect of climate information on livelihoods. Farmers' risk aversion is an important factor in their acreage allocation, crop/livestock choice and input use as extensively reported in the literature (Chavas and Holt 1996; Di Falco and Perrings 2005). Understanding farmers' risk reducing strategies will be essential to fully capture the adjustments made in their farm management as a result of climate information.

**Table 15. Perceived impact (percent)**

| | Eastern | | Kigali | | Northern | | Southern | | Western | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SD | D | SD | D | SD | D | SD | D | SD | D |
| I have a more diversified livelihood portfolio | 5.92 | 53.95 | 5.00 | 35.00 | 2.27 | 47.73 | 6.33 | 46.84 | 19.35 | 53.23 |
| I have a more diversified crop portfolio | 5.26 | 63.82 | 5.00 | 50.00 | 2.27 | 54.55 | 6.33 | 58.23 | 17.74 | 53.23 |
| My crop outputs have been more stable in bad years/ I have less crop damage | 1.33 | 7.33 | 15.00 | 15.00 | 2.27 | 11.36 | 0.00 | 26.58 | 6.45 | 12.90 |
| My livestock/livestock products have been more stable in bad years/ I have less livestock losses | 1.06 | 9.57 | 0.00 | 18.75 | 2.78 | 5.56 | 1.61 | 24.19 | 8.51 | 14.89 |
| My income has been more stable in bad years | 1.97 | 3.95 | 5.00 | 10.00 | 0.00 | 4.55 | 0.00 | 18.99 | 4.84 | 9.68 |
| My income has increased | 1.97 | 19.74 | 5.00 | 35.00 | 0.00 | 13.64 | 0.00 | 20.25 | 8.06 | 24.19 |
| My productive assets have been protected in bad years | 6.58 | 62.50 | 20.00 | 25.00 | 0.00 | 68.18 | 0.00 | 58.97 | 19.35 | 54.84 |
| My crop yields in good rainfall have significantly increased | 12.50 | 78.95 | 25.00 | 45.00 | 0.00 | 68.18 | 6.33 | 63.29 | 27.42 | 53.23 |
| My production costs for crop/livestock have reduced | 5.96 | 37.09 | 10.00 | 25.00 | 2.27 | 54.55 | 0.00 | 34.21 | 8.33 | 48.33 |

## Resilience

The ultimate objective of strengthening access to and use of climate services in Rwanda is to increase agricultural households' resilience to climate change. Resilience is defined as the capacity of a socio-ecological system to maintain its original identity when the outcome is desirable in the face of a stress or to transform to a new stable state when the original system is undesirable (Folke 2006). Resilience is understood as a multidimensional concept that encompasses various angles related to livelihood options, infrastructure, market, ecosystem and institutions. Although resilience, like adaptive capacity, is a latent concept that can be assessed after the shock has taken place, there are a number of characteristics of a system/individual that can be measured and give an indication of whether a system/individual is resilient.

Following the Oxfam GB's approach to measure resilience (Hughes and Bushell 2013), we assume that factors that make individuals resilient to climate shocks include livelihood viability, innovation potential, contingency resources and support access, integrity of natural and built environment, social and institutional capability. Livelihood viability refers to the ability of a household to cope with climate stresses based on his/her livelihood activities. It is assumed that a household engaged in a diverse livelihood portfolio have a higher chance to cope with climate shocks than those pursuing only one precarious activity, all other things being equal. Innovation potential is the second dimension and is related to a household's ability to adjust to changes by anticipating or coping with it. This potential depends on several factors including education/knowledge, attitude toward risk, access to weather, and market information.

The third dimension is access to contingency resource and support. There are times when the well-endowed households become powerless to adjust to climate hazards. In such circumstances, external assistance in the form of food aid, social protection, savings, support network are critical to assist households to adjust or cope with the events. Next, integrity of natural and built environment is essential to enable households to better adapt to climate shocks. Healthy natural resources and appropriate physical infrastructures make a household less sensitive to climate shocks and better able to respond to the shocks. Lastly, social and institutional capability particularly the effectiveness of informal and formal institution to support local communities in times of crisis is also key to confer resilience.

These dimensions are five interrelated components and the specific characteristics of each component are context specific. Annex 3 presents the five dimensions of the resilience index in addition to the indicators selected according to the context. The list is not exhaustive but the indicators selected are considered as relevant to the resilience of households. These factors are combined into a composite resilience index which gives a quantitative measure of resilience at household level. The advantage of such approach is that it can be easy to monitor resilience over time and compare changes between the baseline and ex-post assessments.

We drew on the Alkire-Foster method to operationalize the conceptual framework. We constructed a composite resilience index by adding the weighted indicators for each observation. Similarly to the Ethiopian example in Oxfam GB, we gave a higher weight (30 %) to the livelihood viability dimension as developing strong livelihood is capital for resilience under climate shocks. The dimensions on innovation potential and access to contingency resources are weighted equally at 20%. An enabling environment that promotes and support innovation and access to resources is also fundamental for achieving resilience. Integrity of natural and built environment as well as social and institutional capability are each given less weight (15%) as the ability of households to adjust and cope with climate shocks is strongly related to their own characteristics and efforts rather than those of local leaders and institutions.

Each indicator under the five dimensions is weighted equally and the overall composite index is calculated by adding the weighted indicators for each individual. This index is defined as the Base resilience index. The Alkire-Foster resilience index is constructed by giving a maximum score of one if the individual scores positively on at least two-thirds of the indicators. This index varies from a minimum of zero that depicts very low resilience status to a maximum of one that captures a very high resilience level. It refers to the percentage of households demonstrating greater ability to reduce risk and adapt to emerging trends and uncertainty. In our data set, only 0.5% of the individuals interviewed scored positively on at least two-thirds of the indicators. Because of this, there is almost no difference between the base resilience index and the Alkire-Foster resilience index as reported in Table 16.

**Table 16. Resilience index by gender across provinces (Mean)**

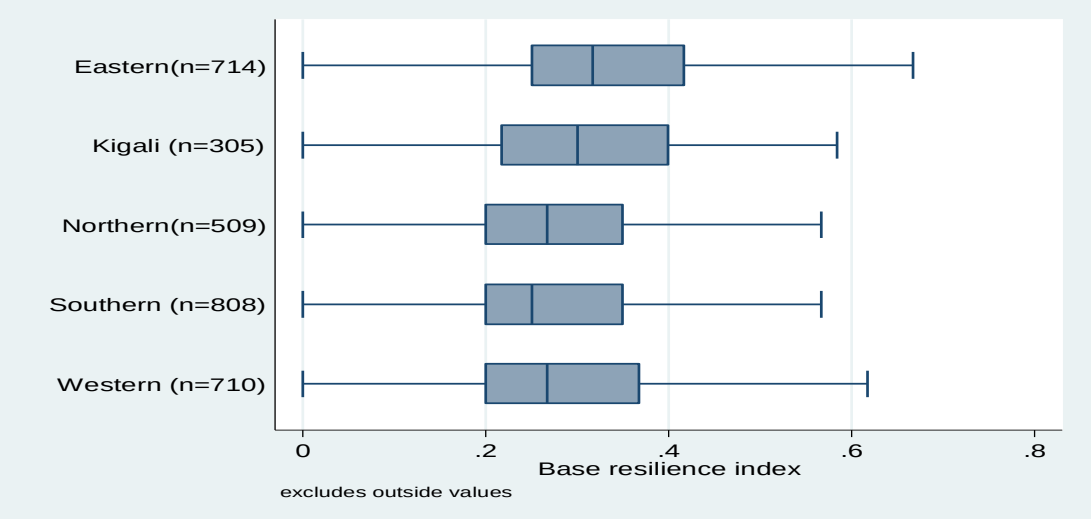
| | Eastern | | | Kigali | | | Northern | | | Southern | | | Western | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference | Female | Male | Difference |
| | Base RI | | | | | | | | | | | | | | |
| $\bar{x}$ | 0.32 | 0.35 | -0.03*** | 0.28 | 0.33 | -0.05*** | 0.25 | 0.29 | -0.04*** | 0.26 | 0.29 | -0.03*** | 0.27 | 0.33 | -0.05*** |
| | Resilience index | | | | | | | | | | | | | | |
| $\bar{x}$ | 0.32 | 0.35 | -0.03*** | 0.28 | 0.33 | -0.05*** | 0.25 | 0.29 | -0.04*** | 0.26 | 0.30 | -0.03*** | 0.27 | 0.33 | -0.05*** |

* p<0.1, ** p<0.05, *** p<0.01

Table 16 further shows that, as expected, women are significantly less resilient than men in all provinces. Similarly to the Poverty Index, the Northern and Southern Provinces are worse off in comparison with other provinces, with the Eastern and Kigali Provinces being better off. This suggests a strong association between poverty and resilience status.

To analyze the variability of the resilience index within and across provinces, we constructed box plots from the base resilience index as illustrated in Figure 31. There is large variability in the index in all provinces but to a lesser extent in the Western and Kigali Provinces.

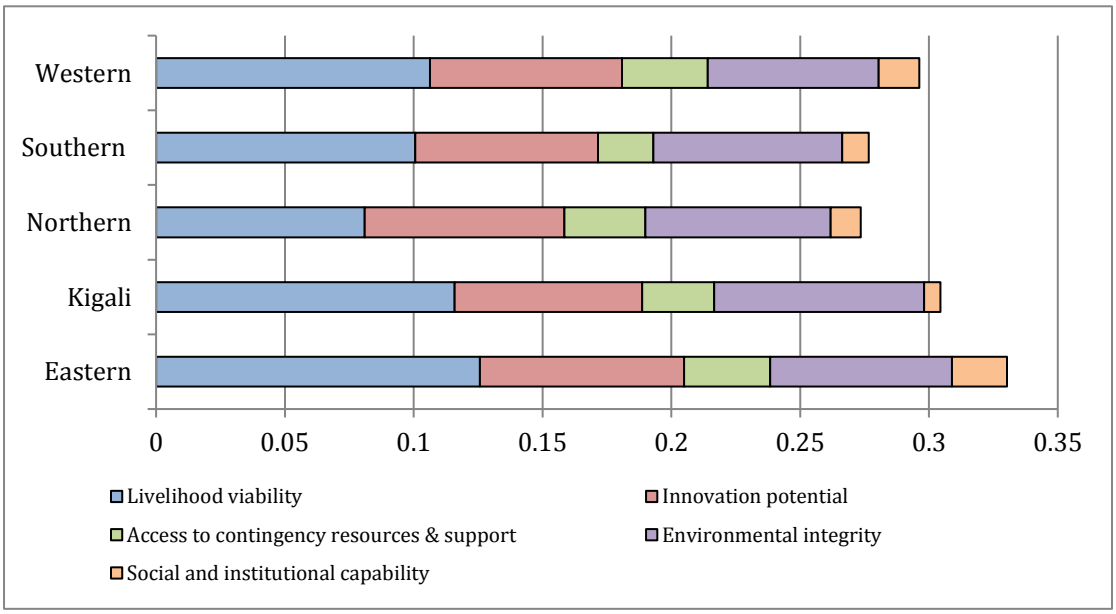
**Figure 31. Box plot of Base resilience index**




We further disaggregated the base resilience index to assess the contribution of each of the five weighted dimensions in the overall index. Figure 32 presents the results of this exercise. The main differences across provinces appear to be in the livelihood viability, access to contingency resources and support and social and institutional capability. These differences shape the outcomes of the resilience index. Livelihood viability has the highest values in the Eastern and Kigali Provinces as expected and the lowest value in the Northern Province. This component includes indicators of crop/livestock/livelihood diversification, poverty status, education level and access to climate information. Access to contingency resources and support is the lowest in the Southern Province. This component encompasses indicators of group membership, access to fungible livestock and confidence in the ability of local government to assist communities in times of crisis. In terms of social and institutional capability that is related to respondents' perception of effectiveness of local leaders/institutions, awareness for community risk disaster reduction strategies and adaptation

plans, the Eastern Province is better off relatively to the other provinces while Kigali is worse off.

**Figure 32. Contribution of the five dimensions in the resilience index**




# Conclusion

This baseline assessment reports results on benchmark indicators related to awareness, access and use of climate information; behavioral changes; and resilience among a sample of 3,046 households, disaggregated by gender, representative of the entire country of Rwanda. The climate information assessed included a variety of products such as indigenous forecasts, seasonal forecasts, daily weather forecasts, forecasts of extreme events and historical climate information. The study results provide a wealth of information that can inform project design, and provide insights into the types of climate information that households have access to, how they receive this information, and their ability to use climate information. Analyses highlight differences by gender and by region.

Overall, there is low access to climate services in Rwanda. Almost no household surveyed had ever received training on climate information. According to the survey, the two most common types of information that households were aware of were indigenous forecasts and seasonal forecasts. The content of climate information delivered included the traditional

information on start of the rainy season, risk of excessive and deficient rainfall, risk of extreme events, end of rainy season, and risk of high or low temperature extremes. Results suggest that there is a great opportunity for the Rwanda Climate Services Project to improve the quality and relevance of climate information currently disseminated by extending available information to include for example distribution of rains and risk of dry spells.

Results showed that women have less access to relevant climate information. Men traditionally have more opportunities to be exposed to information. Men seek more climate information than women, and have a higher level of satisfaction with information received. To increase awareness and access to climate information across the gender, there is a need to deliberately target women through mass media and through social networks including participatory farmer workshops.

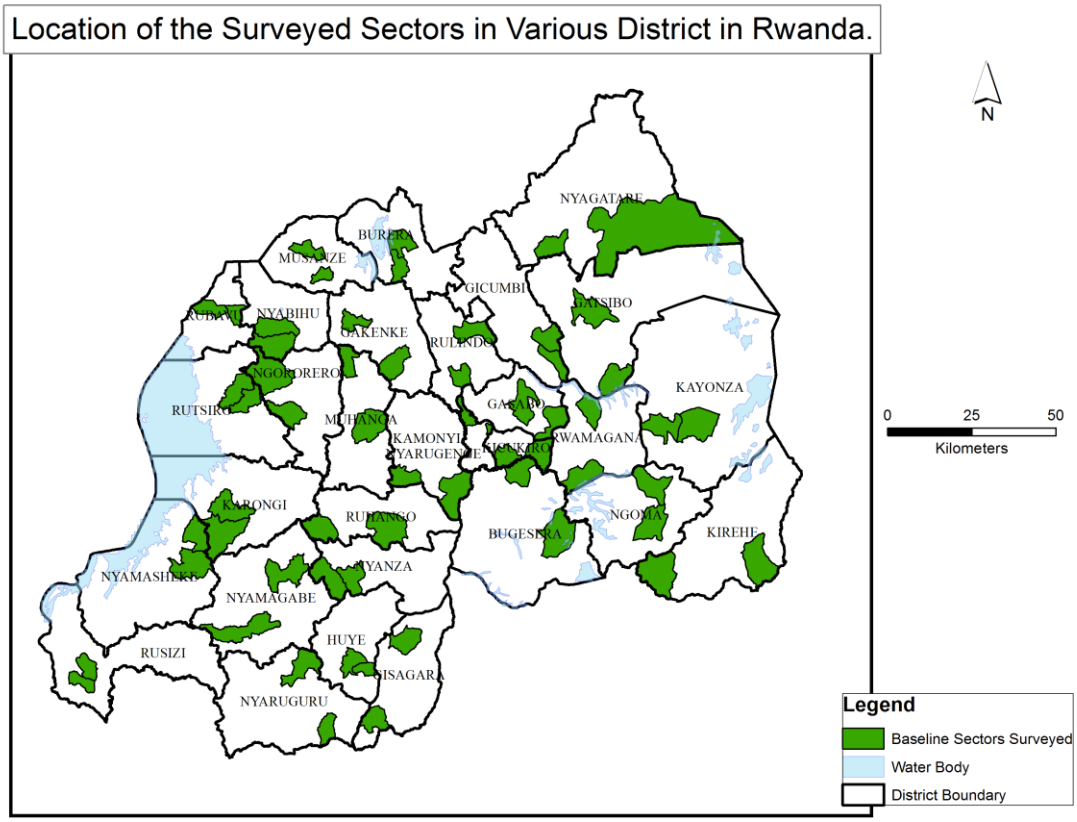
Radio and government extension agents are still the main channels used to communicate climate information. Climate information is not delivered widely through cell phones, although this communication asset is owned by a large majority of the households suggesting that there is great potential in mobile-based climate information.

Constraints identified to using climate information included lack of understanding, and lack of downscaled climate forecasts. Training on climate information through participatory farmer workshops shows promise for fostering awareness, access, understanding and use of climate information in farmers' specific livelihood contexts. Strengthening the enabling environment, particularly in the less endowed districts, in order to increase access to production inputs including seed, fertilizer, equipment, improved technologies will ensure greater uptake and use of the climate information delivered.

The observed lack of influence of available climate information on farm management appears to contribute to low values for resilience indicators. Results also suggest that using climate forecast during a single season has not improved ability to use climate information, therefore services that facilitate uptake and understanding over time may be needed to effect behaviour change.

# Annexes

### Annex 1. Country map and survey sites




### Annex 2. Name of the locations of the survey sites and sample size for each location

| Province | District | Sector | Number of households |
|---|---|---|---|
| North | Burera | Cyeru | 51 |
| North | Burera | Rusarabuye | 51 |
| North | Gakenke | Coko | 51 |
| North | Gakenke | Janja | 50 |
| North | Gicumbi | Giti | 51 |
| North | Musanze | Muko | 102 |
| North | Musanze | Musanze | 51 |
| North | Rulindo | Buyoga | 51 |
| North | Rulindo | Ngoma | 102 |
| South | Gisagara | Musha | 103 |
| South | Huye | Huye | 50 |
| South | Huye | Kigembe | 50 |
| South | Kamonyi | Mugina | 49 |
| South | Kamonyi | Nyarubaka | 50 |

| | | | |
|---|---|---|---|
| South | Muhanga | Kabacuzi | 47 |
| South | Muhanga | Nyabinoni | 51 |
| South | Nyamagabe | Kaduha | 51 |
| South | Nyamagabe | Uwinkingi | 51 |
| South | Nyanza | Rwabicuma | 51 |
| South | Nyaruguru | Mata | 51 |
| South | Nyaruguru | Nyagisozi | 102 |
| South | Ruhango | Kabagali | 51 |
| East | Bugesera | Gashora | 51 |
| East | Bugesera | Mwogo | 51 |
| East | Gatsibo | Gitoki | 51 |
| East | Gatsibo | Kiramuruzi | 51 |
| East | Kayonza | Nyamirama | 51 |
| East | Kayonza | Rwinkwavu | 51 |
| East | Kirehe | Gahara | 51 |
| East | Kirehe | Nyamugari | 51 |
| East | Ngoma | Kazo | 51 |
| East | Ngoma | Rurenge | 51 |
| East | Nyagatare | Karangazi | 51 |
| East | Nyagatare | Mimuri | 51 |
| East | Rwamagana | Karenge | 51 |
| West | Karongi | Rwankuba | 51 |
| West | Karongi | Twumba | 50 |
| West | Ngororero | Muhanda | 52 |
| West | Ngororero | Sovu | 51 |
| West | Nyabihu | Muringa | 50 |
| West | Nyabihu | Rambura | 51 |
| West | Nyamasheke | Karambi | 52 |
| West | Nyamasheke | Mahembe | 50 |
| West | Rubavu | Kanzenze | 51 |
| West | Rubavu | Rubavu | 48 |
| West | Rusizi | Gitambi | 52 |
| West | Rusizi | Rwimbogo | 50 |
| West | Rutsiro | Murunda | 51 |
| West | Rutsiro | Ruhango | 102 |
| Kigali | Gasabo | Bumbogo | 51 |
| Kigali | Gasabo | Rusororo | 51 |
| Kigali | Kicukiro | Gahanga | 51 |
| Kigali | Kicukiro | Masaka | 51 |
| Kigali | Nyarugenge | Kanyinya | 51 |
| Kigali | Nyarugenge | Mageragere | 50 |
| Total | | | 3046 |

## Annex 3. Details on the resilience index adapted from Oxfam

| Dimension | Indicator | Measurement Approach | Criterion | Indicator weight |
|---|---|---|---|---|
| Livelihood viability | Poverty status | Progress out of Poverty Index | Household scoring more than 44 (50% likelihood of not be poor) | 1/20 |
| | Livelihood diversification | Respondent is asked specific questions about livelihood activities undertaken by household during the previous 12 months | Household undertook at least two livelihood activities, with at least 1 being largely unaffected by potential drought or flooding | 1/20 |
| | Crop diversification | Respondent is asked specific questions about the types and number of crops planted in previous 12 months | Household grew at least three crop varieties during previous 12 months | 1/20 |
| | Livestock portfolio | Respondent is asked about the types of livestock owned by the household | Household possesses at least 2 varieties of livestock, with at least one considered hardy to adverse climate conditions, e.g. goats, sheep, or camels. | 1/20 |
| | Climate forecasting info. access | Respondent is asked to rate his/her household's access to reliable climate forecasts | Respondent reports having no problems or only small problems access such information | 1/20 |
| | Extension support | Respondent is asked whether his/her household received extension support in previous 12 months and, if so, the number of times | Respondent reports having had received extension support more than 1 time during the previous 12 months | 1/20 |
| Innovation potential | Credit access | Respondent is asked whether his/her household took out a loan during the previous 12 months | Respondent reports that household took out loan during the previous 12 months from formal, informal or NGOs/government | 1/20 |
| | Market access | Respondent is asked to rate his/her household's access to markets on a five point ordinal scale | Respondent reports having no problems or only small problems accessing markets to purchase agricultural inputs | 1/20 |
| | Awareness of climate change | Respondent is asked whether is aware about climate change issues (change in temperature, rainfall) | Respondent reports having no problems or only small problems accessing reliable market information on crop and livestock prices | 1/20 |

| Dimension | Indicator | Measurement Approach | Criterion | Indicator weight |
|---|---|---|---|---|
| | Education, literacy | Respondent is asked on the number of years of education | Respondent reports having at least 5 years of formal education. | 1/20 |
| Access to contingency resources & support | Group membership | The respondent is asked whether s/he had participated in various groups over the past year | Respondent reports participation in at least 3 groups with significant decision-making in at least 1 of these. | 1/15 |
| | "Fungible" livestock | Respondent is asked about the number of goats/sheep and poultry birds that s/he owns | Respondent reports that their household possesses at least 3 goats/sheep or at least 5 poultry birds | 1/15 |
| | Confidence in local gov. | Respondent is read 5 statements about the responsiveness of local government and leaders in times of drought or flood and asked the extent to which they agree with each | Respondent agrees at least to a medium extent to 4 out of the 5 statements. | 1/15 |
| Integrity of natural and built environment | Soil erosion | Respondent is asked about his/her perception of soil erosion in his/her fields | Respondents report that their soil quality is at least of a medium quality | 1/20 |
| | Access to irrigation | Respondent is asked whether any of the fields cultivated in the last 12 months were irrigated. | Household reports at least 1 of their fields was irrigated. | 1/20 |
| | Grazing land access | Respondent is asked to rate their household's access to grazing land or use of fodder on a five point ordinal scale | Respondent reports household only experiencing small problems or no problems accessing suitable grazing lands or fodder during last dry season | 1/20 |
| Social and institutional capability | Perception of effectiveness of local leaders/institutions | Respondent is asked to rate his/her level of agreement with statements on effectiveness of local leaders/institutions | Respondents agrees to a medium extent with 5 out of 6 positively phrased statements | 1/20 |
| | Awareness of community risk disaster reduction strategies | Respondent is asked whether s/he is aware of any community level risk disaster reduction strategies | Respondent reports to be aware of at least 2 community level initiatives taken place in past 2 years | 1/20 |
| | Awareness of local/leaders community/institution action on adaptation | Respondent is asked whether s/he is aware that the community leaders/institutions are undertaking some actions on adaptation | Respondent reports being at least partly aware that the community leaders/institutions are doing something on adaptation front | 1/20 |

# References


Bryan, E., Deressa, T.T., Gbetibouo, G.A. Ringler, C. 2009. "Adaptation to climate change in Ethiopia and South Africa: options and constraints." *Environmental Science and Policy* 42: 413-426

Chavas, J.P., and M.T. Holt. 1996. "Economic Behavior Under Uncertainty: A Joint Analysis of Risk Preferences and Technology." *Review of Economics and Statistics* 78:329–35.

Deressa, T.T., Hassan, R.M., Ringler, C. 2011. "Perception of and adaptation to climate change by farmers in the Nile Basin of Ethiopia." *Journal of Agricultural Science* 149:23-31.

Di Falco, S., Perrings, C., 2005. "Crop biodiversity, risk management and the implications for agricultural assistance." *Ecological Economics* 55: 455-466.

Folke, C. 2006. "Resilience: the emergence of a perspective for social-ecological systems analysis." *Global environmental change* 16:253-267.

Hughes, K. A. & Fuller, R. 2013. Disaster Risk Reduction Programming in Ethiopia's Somali Region - Effectiveness Review: Full Technical Report. Oxfam GB.

Maddison, D. 2007. The Perception of and adaptation to climate change in Africa. Policy Research Working Paper 4308. The World Bank Development Research Group.

Mutabazi, A. 2011. Rwanda country situational analysis. Working paper, May 2011

NSIR.2012. The evolution of poverty in Rwanda from 2000 to 2011: results from the household surveys (EICV), Kigali 2012.

Schreiner, M. 2016. Simple Poverty ScoreCard Rwanda. http://www.simplepovertyscorecard.com/RWA_2010_ENG.pdf

Stockholm Environment Institute (SEI). 2009. Economics of climate change in Rwanda. https://www.weadapt.org/sites/weadapt.org/files/legacy-new/knowledge-base/files/4e2572b33fe5bPresentation_summary.pdf

USAID. 2016. GCC Standard Indicator Handbook. https://www.climatelinks.org/resources/gcc-standard-indicator-handbook

Visman, E., Tall, A., Ewbank, R., Diop Kane, M., Jones, R. 2012."Making climate science useful: cross-regional learning from Kenya and Senegal." In Climate Exchange. World Meteorological Organization.

RESEARCH PROGRAM ON
**Climate Change, Agriculture and Food Security**

CGIAR

CCAFS

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic initiative of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT). CCAFS is the world's most comprehensive global research program to examine and address the critical interactions between climate change, agriculture and food security.

**For more information, visit www.ccafs.cgiar.org**

Titles in this Working Paper series aim to disseminate interim climate change, agriculture and food security research and practices and stimulate feedback from the scientific community.


CCAFS is led by: CIAT

Strategic partner: futureearth research for global sustainability

Research supported by:

CGIAR Fund · Australian Government Australian Centre for International Agricultural Research · Irish Aid · Ministry of Foreign Affairs of the Netherlands · New Zealand Ministry of Foreign Affairs & Trade · Swiss Agency for Development and Cooperation SDC · UKaid · USAID From the American People · IFAD