International Journal of Agricultural Science, Research and Technology in Extension and Education Systems (IJASRT in EESs)
Available online on: http://ijasrt.iau-shoushtar.ac.ir
ISSN: 2251-7588 Print
ISSN: 2251-7596 Online
2018: 8(1):29-42

Received: 10 June 2017
Reviewed: 27 June 2017
Revised: 30 June 2017
Accepted: 30 July 2017

Smallholder Farmers' Access to and Use of Scientific Climatic Forecast Information in Mt. Elgon Area, Eastern Uganda

Mubangizi Narisi [1*], Kyazze Florence Birungi[2] & Mukwaya Paul[3]

[1&2] Department of Extension and Innovation Studies, Makerere University, P.O.Box 7062, Kampala, Uganda.
**Corresponding Author Telephone: +256-776-354777 E-mail: mubnarisi@caes.mak.ac.ug*
[3] Department of Geography, Geo-informatics and Climatic Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda.

Keywords: Scientific climate forecast information, Access, Timing, Agricultural production decisions.

Abstract

Proper use of climatic forecast information in planning and implementing agricultural activities is critical for the improvement of the wellbeing of smallholder farmers whose livelihoods depend on rain-fed agriculture. This study employed a descriptive cross-sectional design involving 12 focus group discussions and 255 household interviews to determine the extent to which smallholder farmers in Mount Elgon Region of Eastern Uganda accessed and used climate forecast information. Results showed that 84% of the farmers had received scientific climate information especially on timing of onset and cessation of rainfall and likelihood of landslides. The information was mainly accessed through radio and rarely from extension workers and fellow farmers. Over 60% of farmers considered the different types of climatic forecast information received to be less reliable and inappropriately timed relative to their needs and this barred most of them from applying it in their agricultural production decisions. The likelihood to use climate forecast information was enhanced by farmers' formal education, ownership of a radio set, perception that the information was reliable and timely. Thus efforts to enhance farmers' use of rainfall forecast information customize it to the needs of the targeted farmers.

1. Introduction

Smallholder farmers in Sub-Sahara Africa (SSA) are more vulnerable to adverse effects of uncertain rainfall because of their dependence on rain-fed agriculture (Alliance for a Green Revolution in Africa [AGRA], 2014). The frequency and severity of the uncertain rainfall and climate extremes are projected to increase due to climate change and climate variability (Cooper *et al*., 2008; IPCC, 2014). These climate extremes and uncertain rainfall patterns threaten smallholder farmers' livelihoods through their adverse affects on their agricultural production and productivity. In order for smallholder farmers to sustain their livelihoods, they need to take up appropriate measures to improve their agricultural production within the context of the current and projected climatic uncertainties (Hisali, Birungi & Buyinza, 2011). The measures taken by farmers in response to climatic uncertainties are largely shaped by the information they have about the nature, magnitude and effects of the expected climatic conditions as well as strategies to deal with such effects (Gukurume, 2013, Jiri, Mafongonyo, Mubaya & Mafongonyo, 2016). Accordingly, smallholder farmers' access and use of climatic forecast information is vital to enable them cope with and adapt to climatic uncertainties (Kaggwa, Hogan, & Hall, 2009; Hansen, Mason, Sun & Tall, 2011; Gukurume, 2013; Moeletsi, Mellaart, Mpandeli, & Hamandawana, 2013; Okonya & Kroschel, 2013).

Coping and adaptation actions are usually planned for prior to the onset of the rainfall season in order for them to enable farmers to reduce adverse impacts of climatic uncertainties and take advantage of any good climatic conditions (AGRA, 2014). Thus, climatic forecast information to inform the planning of such coping and adaptation actions should correctly forecast the future climatic conditions in addition to being availed at a time when the targeted users (farmers) need it (Gyampoh & Asante, 2011, Lemos, Kirchoff & Ramprasad, 2012). The extent to which the climatic forecast information correctly forecasts the climatic conditions it purports to forecast is what is referred to as reliability in this paper.

Smallholder farmers can access climatic forecast information from both science-based meteorological forecasts and indigenous knowledge (Ziervogel & Opere, 2010, Jiri *et al*., 2016). Smallholder farmers in SSA and elsewhere in the world have traditionally relied on indigenous knowledge to understand weather and climate patterns in order to make decisions about their agricultural activities (Ziervogel & Opere, 2010; Nganzi, Kajumba, Barihaihi, Bataze, & Mujuni, 2015). However, reports indicate that indigenous knowledge based forecasts are becoming unreliable as a result of climate change which has altered the climatic patterns on which they are based (Chang'a, Yanda & Ngana, 2010; Egeru, 2012; Masinde & Bagula, 2012; Nganzi *et al*., 2015, Jiri *et al*., 2016). Therefore to enhance smallholder farmers' abilities to cope with climatic uncertainties resulting from climate change and climate variability, most countries in SSA and elsewhere have directed considerable attention towards the provision of scientific climatic forecasts (AGRA, 2014).

In Uganda, meteorological rainfall forecasts are generated by Uganda National Meteorological Authority (UNMA). In generating the forecasts, UNMA uses the conventional approach which is dependent on scientific procedures of climatic modeling and empirical data (Ziervogel & Opere, 2010). UNMA produces seasonal rainfall forecasts that focus on the onset, cessation and distribution of rains and the anticipated effects of the forecasted rains enable farmers to reduce production losses and take advantage of good rains. In attempt to downscale the forecasts, UNMA subdivided Uganda into 16 climatological zones each composed of four to twenty districts that have relatively similar climatic conditions (Nganzi *et al*., 2015). UNMA disseminates the climatic forecast information on a seasonal basis in the dominant local languages in the particular zones mainly using newspapers, local radio stations and UNMA website (Ministry of Water and Environment [MWE], 2015). The Mount Elgon Region in Eastern Uganda is part of what UNMA classifies as the Eastern Central Climatological Zone which is composed of 19 districts (UNMA, 2017). UNMA disseminates the seasonal climatic forecasts in this zone in the dominant local languages in the area including Ateso, Kumam, Lumasaba and Sabiny (UNMA,2017).

Despite the considerable efforts in disseminating climatic forecast information to different parts of the country, farmers continue to register losses due to climate-related factors. For instance, the Uganda agricultural census of 2008/09 noted that two million agricultural households in Uganda experienced food shortages because of the erratic rainfall seasons (Uganda Bureau of Statistics [UBOS], 2010). Similarly, an assessment of the impact of the rainfall variability in 2010-2011 conducted by the Department of Disaster Preparedness [DDP] (2012) under the Office of the Prime Minister indicated that losses of approximately two trillion Uganda shillings (equivalent to about 900 million United States Dollars) were incurred in form of crop failure, reduced livestock production and deaths. Currently, it is not clear why farmers continue to incur agricultural losses due to rainfall variability despite the existing efforts of disseminating seasonal climatic forecasts to enable them prepare for the expected climatic conditions. Specifically, there is scanty information regarding the extent to which the targeted farmers access and use the disseminated climate forecast information in their agricultural operations. This study therefore sought to establish smallholder farmers’ access to and use of rainfall forecasting knowledge in Mt. Elgon area in eastern Uganda. To achieve this objective, the study answered four critical questions; i) What type of rainfall forecast-related information do farmers in Mt. Elgon area have access to? ii) What are the farmers' perceptions about the reliability and timing of the rainfall forecast information they access? iii) What agricultural decisions do farmers make based on the rainfall forecast information they access? and; iv) What factors determine the likelihood of farmers to use scientific information on rainfall forecasting?

2. Materials and methods

Description of the study area

Mount Elgon Region in Eastern Uganda is composed of eight districts namely; Mbale, Manafwa, Bududa, Sironko, Bulambuli, Bukwo, Kween and Kapchorwa. The region covers about 4,200 square kilometers of land area. The region is home to 1,773,822 people of whom about 87% are rural based (UBOS, 2015). The region is characterized by steep terrain and a high population density of over 280 persons per square kilometer (Mbogga, 2012) compared to the national average of 174 persons per square kilometer (UBOS, 2014). In terms of climatic conditions, the mean annual rainfall for the region ranges from 1500 mm on the eastern and northern slopes, to 2000 mm in the southern and the western slopes and with mean maximum and minimum temperatures of 23°Cand 15°C respectively (Mugagga, Kakembo & Buyinza, 2012). These climatic conditions are favourable for the production of various types of crops and livestock. Therefore, rain-fed agricultural production is the dominant source of livelihood. However due to the steep terrain and high population density, the agricultural production in the area is on a small scale mainly.

The majority of the people in the region belong to the Gishu and Sabiny tribes. The Gishu whose local language is Lumasaba occupy the districts of Mbale, Manafwa, Bududa, Bulambuli and Sironko while the Sabiny occupy Kapchorwa, Kween and Bukwo districts. UNMA disseminates seasonal climate forecasts, monthly climate outlooks, daily weather forecasts and warnings about the likelihood of climatic disasters in English and the dominant local languages (Ateso, Kumam, Lumasaba and Sabiny) through radio, television, print media and the website.

Research design

The study employed a descriptive cross sectional design to gather data about farmers' access to and use of rainfall forecasting information. The main data collection method was a survey that was complemented by Focus Group Discussions (FGDs) to obtain in-depth understanding about farmers' perceived reliability, timing and use of rainfall forecasting information. On one hand, the FGDs were used to inform the development and fine-tuning of the survey instrument as well as providing contextual description and explanation of key issues in the study. On the other hand, the survey sought to generate data that could provide a basis for generalization of the findings for the Mt. Elgon region and beyond.

Sampling and subject selection

Bududa and Manafwa districts were purposively selected from Mt. Elgon agro-ecological zone because they depict unique demographic and biophysical features. The terrain and population density in the two districts reflect the situation in Mt. Elgon region as a whole. Additionally, these two districts were selected because they regularly experience rainfall variability challenges for example; landslides and food shortages due to prolonged dry spells (UBOS, 2010).

Following the same criteria used to select districts, six sub-counties were purposively selected namely; Khabutoola, Nalondo and Bugobero for Manafwa district; Bushika, Bukalasi and Bumasheti for Bududa district (Figure 3.1). In each sub-county, three villages were also purposively selected with guidance from the respective Local Council 1 chairpersons and sub-county agricultural officers. Preference was given to villages that were perceived to have recently been affected by changes in rainfall patterns and their associated shocks.

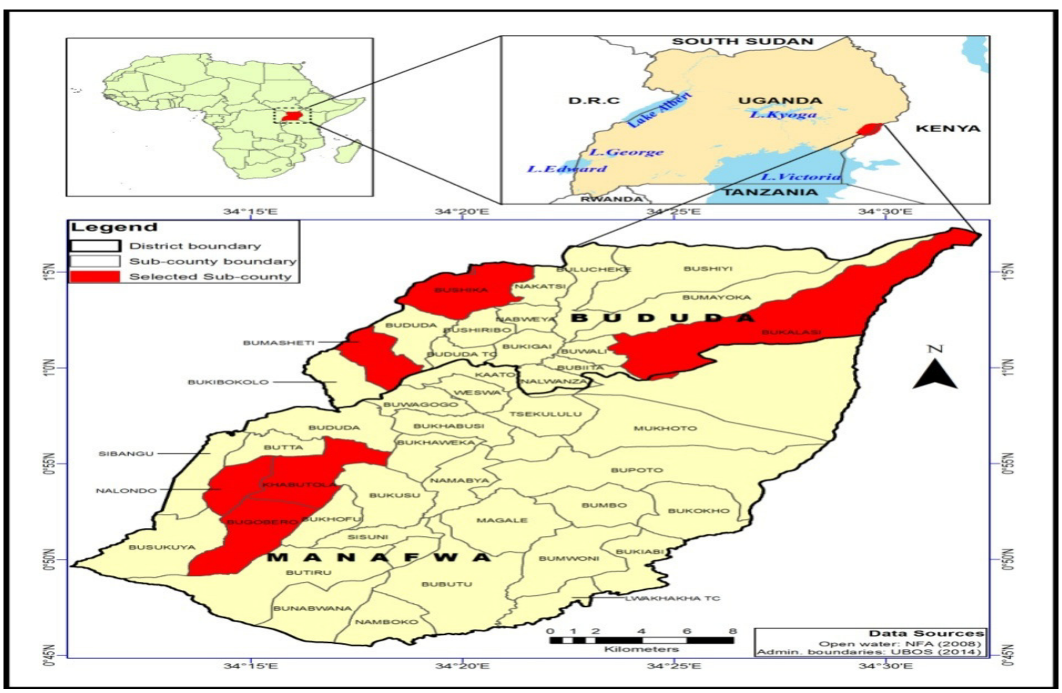

Figure 1. Location of study sub-counties

A total of 123 (62 males and 61 females) were purposively selected to participate in the FGDs based on gender and experience in farming in the area. Preference was given to both male and female farmers who had been practicing farming in the selected villages for at least 10 years. These were considered to posses more knowledge and experience regarding farmers' access to and use of climate forecast information in the area. Relatively equal numbers of male and female farmers were targeted for the FGDs to ascertain whether there were any differences between males and females with regard to access and use of climate forecast information. Based on the above criteria, the specific individuals involved in the FGDs were identified with guidance from the sub-county agricultural officers and respective village local council chairpersons. On average, seven people were selected from each village to participate in the FGDs. The FGDs were held at the respective sub-county headquarters.

Households to participate in the survey were obtained through proportionate stratified random sampling. The strata were the 18 villages selected for the study. The number of households drawn from each village was proportional to the total number of households in that village (at least 10% of the households in each village had were selected for the study). The sampling frame comprised of all households in all the 18 selected villages in the six sub-counties. Lists of all households in the villages were generated by the respective village chairpersons and three other members of the village local council (LC 1) committee. The names of household heads from all the villages were compiled to form a sampling frame of 2,124 households. Basing on this sampling frame, the sample size was computed using the formula by Krejcie & Morgan (1970). The calculated sample size was 236. However, to cater for the non-response, the estimated sample size was increased by 10% resulting into a sample of 255. The number of households drawn from each village was then obtained through proportionate random sampling.

Instrumentation and data collection

Data collection was conducted in two phases. The first phase involved 12 FGDs which were facilitated using a checklist that had been developed with input from two scholars from Makerere University and reviewed by peers for content validity. The FGDs focused on gathering in-depth data on the sources, access and use of climate forecast information. The data from the FGDs helped to focus the study, develop the survey tool and provide detailed explanations for the survey findings.

The second phase involved a survey during which semi-structured interviews were conducted with 255 households. In each household, only the household head or the spouse was interviewed. The semi-structured interviews (SSIs) focused on collecting quantitative data on household socio-economic and demographic characteristics, sources of information, access, and use of climate forecast information. The SSIs also focused on collecting data about farmers' perceptions about the reliability and timing of climate forecast rainfall information accessed. In assessing the reliability of the rainfall forecast information, this study drew insights from the concept of the hit rate normally used to assess quality of forecasts over a long time (Sultan, Barbier, Fortilus, Mbaye, & Leclerc, 2010). The hit rate refers to the proportion of forecasts that agree with what eventually happens in reality (Sultan et al., 2010). In line with this concept, reliability of the forecasts was assessed by capturing farmers' perceptions about the extent to which the forecasts correctly projected the actual weather conditions they forecasted. To avoid challenges associated with recall and also ensure easy comparison of responses from different farmers, the study used the forecasts received in the previous one year (2015) as the point of reference. The reliability was measured using a rating scale with the following scores 1= Very low; 2= Low; 3= High; 4= Very high).

The timing of the information was measured in terms of time the information was provided relative to when the farmers needed. This was done using the following rating scale; 1= Early; 2= Just on time; 3= Late). The survey questionnaire used in the SSIs was developed with input from two scholars from Makerere University for clarity of the questions and content validity. The questionnaire was also pre-tested on 16 farmers in Ikaali parish, Bukhofu sub-county in Manafwa district to enhance its suitability. Prior to data collection, research assistants were trained and involved in the pre-testing to acquaint them with the tool and ensure quality of the data collected.

Data analysis

Data from FGDs was analyzed through manual content analysis to identify key emerging issues. Data from the SSIs was analyzed using Statistical Package for Social Sciences (SPSS) version 21 to produce frequencies and means to describe the characteristics of the study respondents. Frequencies and percentages were also used to describe farmers' access, perception about reliability and timing of the information as well as the extent of use of different types of climatic information. A binary logistic regression model was used to establish the factors that influence the use of scientific information on forecasting onset of rainfall.

The dependent variable in the binary logistic regression model was whether a farmer used the scientific climate information on timing of onset or not. The binary choice was dummied as 1 if a farmer used the information on timing of onset and 0 for otherwise. The selection of predictor variables included in the model was based on theory and data availability.

Suppose Y is the decision to use the information on timing of onset of rains which is a random variable and X are the socioeconomic factors, farm characteristics, awareness of indigenous indicators for onset of rains and perceptions about the reliability and timing of information on onset of rains presumed to predict the decision to use or not to use the information.

The probability of Y can be predicted from the range of predictor variables through equation 1 given by Field (2009).

$$P(Y) = \frac{1}{1+e^{-(\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\,\dots\dots\beta_nX_n+\mu)}} \quad \dots\dots\dots(1)$$

P(Y) is the probability of a farmer using the information on timing of onset of rains

X_1 to X_n are independent variables presumed to predict the probability of a farmer using the information on timing of onset of rains

β_0 is the Y-intercept

β_1 to β_n are the coefficients (weights) attached to each of the predictors x_1 to x_n

μ is the error term

The above coefficients are only used to show the direction of the relationship between the dependent variable and the specific predictor variable (Deressa, Hassan, Ringler, Alemu & Yusuf, 2009). In order to indicate the magnitude of the influence that a specific predictor variable has on the dependent variable, odds ratios are used. The odds ratio corresponding to a given predictor variable represent the change in odds of using information that occurs as a result of unit change in the predictor variable divided by the original odds. Thus an odds ratio of more than one indicates that as the predictor increases, the odds of the using information increase while a value of less than one shows that as the predictor increases, the odds of the outcome occurring decrease (Field, 2009).

Given that the probability of using the information =P(Y) and the probability of not using the information = 1- P(Y), then the odds of using the information is given by;

$$\frac{P(Y)}{1-P(Y)} \quad \dots\dots\dots(2)$$

Combining equations (1) and (2) , the odds of using the information can be given by;

$$\frac{\frac{1}{1+e^{-z}}}{1-\frac{1}{1+e^{-z}}} \quad \dots\dots\dots(3)$$

where z=

$$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\ \dots\beta_nX_n+\mu$$

The above equation can be simplified by finding the natural logarithm

$$\mathrm{Ln}\left(\frac{\frac{1}{1+e^{-z}}}{1-\frac{1}{1+e^{-z}}}\right)=Z$$

$$\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\ \dots\beta_nX_n+\mu \quad \dots\dots\dots(4)$$

The odds radio corresponding to a given predictor variable (X_1) were computed as a the odds of using forecast information after a unit change in X_1 divided by the original odds.

Table 1 below shows how the predictors included in the model were operationalized and their hypothesized influence on farmers' use of climatic information to make production decisions.

Table 1. Description of the predictor variables entered into the empirical model

Predictor variables	Definition (How the predictor was defined in this chapter)	Expected sign /relationship
X_1= Gender	1 for male and 0 for female	+
X_2= Group membership	1 for yes and 0 for no	+
X_3= Ownership of radio	1 for yes and 0 for no	+
X_4= Age	Years	+
X_5=Highest education level in the household	Years of schooling	+
X_6= Household size	Number of members	+
X_7= Farm size	Acres	+
X_8= Off-farm income sources	Count of off -farm income sources	-
X_9= Perceived reliability of information on onset rain	1 for reliable (very high or high reliability) and 0 for otherwise (low or very low reliability)	+
X_{10}= Perceived timing of information on onset	1 for Just on time and 0 for otherwise (late or early)	+

3. Results and discussion

This section presents findings for farmer access to and use of scientific and indigenous knowledge on rainfall forecasting.

3.1 Farmers' demographic and socio-economic characteristics

The socio-economic and demographic characteristics varied among the respondents as indicated in Table 2. About 66% of the respondents were males. The larger proportion of males in the sample is explained by the cultural set up in the study area where households are identified by the headship that are pre-dominantly male. Indeed, about 93% of the households involved in the study were male headed. Over 75% of the households involved in the study had one or more members who belonged to one or more community based groups. The high proportion of households with membership in community based groups implies that targeting such groups with services and information can help in reaching most of the households in the area. Furthermore the majority of households (88%) owned one or more radio sets implying that information disseminated through radio may be received by most of the households in the area. The results further reveal that the average age of the farmers was 43 years implying that the respondents had substantial experience in farm related activities. The average number of highest years of formal education in the household was approximately seven which corresponds to completion of primary level of education. The average family size was seven persons which is also most double the national average family size of five persons (UBOS, 2014). Having large households yet farm sizes are small (an average of 2.8 acres per household) implies that farmers should maintain high agricultural yields if they are to sustainably meet their households' food and non-food needs. Given the increasing unpredictability of climatic conditions, farmers can only increase and maintain their agricultural productivity if their agricultural activities are planned and implemented based on accurate information about future climatic conditions (AGRA, 2014).

3.2 Smallholder farmers' access to and use of scientific climate information

Farmers need access to climatic information in order to maintain and/or improve their agricultural production amidst increasing climatic uncertainties (Kaggwa et al., 2009; Gukurume, 2013; Moeletsi et al., Okonya & Kroschel, 2013, AGRA, 2014). Farmers can access different types of climatic information from different sources and channels.

3.3 Types and sources of scientific climate information accessed by farmers

Results from this study indicate that majority (84%) of the farmers in the study area received scientific rainfall forecast information during the previous one year (2015). The pieces of scientific forecast information received by the farmers were largely related to the timing of onset and cessation of rainfall seasons and the likelihood of occurrence of climate extremes particularly landslides (see Table 3).

The predominance of information on the timing of onset and cessation of rains indicates that these are the most critical types of agro-meteorological climatic information (Nganzi et al. 2015; Egeru, 2016) that inform farmers' investment decisions (AGRA, 2014). Furthermore, information about the likelihood of landslides was also among the most accessed types of information because the study area is traditionally prone to landslides (Knapen et al., 2006; Mugagga et al., 2012).

The Uganda National Meteorological Authority (UNMA) was the major source of scientific climate information for the farmers in the study area. This is because UNMA has the national mandate to collect, analyze and disseminate climate information throughout the country. However, less than 20% and 6% of the farmers had accessed any scientific climate information from fellow farmers and agricultural extension workers respectively. The small proportion of farmers accessing scientific climate information from fellow farmers shows that farmers do not share the information after receiving it from UNMA. Conversations with farmers during FGDs revealed that they refrained from sharing scientific climatic information because of its inaccuracy in predicting weather forecast. Other farmers did not share scientific climatic information heard over the radio because they presumed that everybody else had heard it. The limited sharing of scientific climate information amongst farmers compromises joint reflections that would enhance widespread use of the information (Kibwika, 2007).

The limited number of farmers who had accessed scientific information from extension workers is attributed to poor extension worker to farmer ratio and the perception among the extension workers that dissemination of climate information was not their official obligation. Each of the study sub-counties had only one government agricultural extension worker. This translates into an extension worker/farmer ratio of 1: 2898 based on the average number of households per sub-county reported in the 2014 national housing and population census. This ratio closely compares with the average of 1 extension worker for 3,189 farmers for Uganda reported by Danielson, Karubanga & Mulema (2015). Besides the poor extension worker to farmer ratio, discussions with extension workers in the study sub-counties further revealed they had never been officially requested to participate in the dissemination of climatic information to the farmers. Furthermore, the extension workers revealed that they had never been allocated any resources to facilitate them to disseminate climatic information and guide farmers to interpret and correctly use such climatic information.

Table 2. Demographic and Socio-Economic Characteristics of Farmers Involved in the Study

Predictor variables	Sample statistics (n=255)	
	%	Means
Proportion of respondents who were males	66.0	
Proportion of male headed households	93.3	
Proportion of female headed households	6.7	
Proportion of households with members in farmers' groups	78.0	
Proportion of households owning radio sets	88.0	
Age of the respondent in years		42.7
Highest level of education in the household (years of schooling)		7.1
Household size (number of members)		7.3
Farm size (acres)		2.8

Table 3. Types of scientific climate forecast information received and their sources

Type of climate information	Percentage of farmers accessing different types of information from each source (n=255)			
	UNMA	Fellow farmers	Local leaders	Extension workers
Timing of onset of rains	71.7	16.5	3.5	5.1
Likelihood of occurrence of landslides	54.5	19.1	10.6	2.3
Timing of cessation of rains	53.4	9.9	2.7	0.8
Projected amount & distribution of rains over the next 2-3 months	47.1	1.9	0	0.7
Weather forecast for next 1-3 days	42.7	5.9	0	0.4

Table 4. Channels used to disseminate scientific climatic forecast information dissemination

Channels	Percentage of farmers who received the different types of climate information from the different channels (n=255)				
	Timing of onset	*Timing of cessation*	*Amount & distribution of rain over 2-3 months*	*Weather forecast 1-3 days*	*Likelihood of landslides*
Radio	78.8	64.1	50.6	43.0	58.0
Face to face	29.3	12.7	3.5	6.3	33.0
Television	2.7	2.7	2.4	0.4	3.0
Printed materials	0.4	0	0	0.0	1.2

Table 5. Farmers' rating of the reliability of the scientific forecast information received

Type of information	Number of farmers who accessed information	Perceived reliability of the information (Percentages of farmers)			
		Very low	*Low*	*High*	*Very high*
Timing of onset of rains	223	32.5	42.9	13.7	10.9
Likelihood of landslides	161	24.2	42.4	11.5	21.9
Timing of cessation of rains	153	30.3	39.0	9.3	21.4
Amount, intensity and distribution of rain over the next 2-3 months	133	45.1	33.6	8.6	12.7
Forecast of weather for 1-3 days	80	14.3	43.4	8.5	33.8

3.4 Channels through which farmers receive scientific climatic forecast rainfall information

Farmers accessed scientific climate information through different channels as indicated in Table 4.

Radio was the most dominant channel used to disseminate scientific forecast information. Other channels that were used included face to face (word of mouth), television and printed materials. Conversations with farmers during FGDs indicated that the information was mainly aired in the local language (Lumasaba) on the local radio stations especially Open Gate FM, Step FM, Rock FM and Elgon FM. The use of radio as the main channel for disseminating scientific forecast information is probably attributed to its capacity to simultaneously reach out to many people. These findings about the dominance of radio as a key channel for disseminating rainfall information are consistent with those of Gyampoh & Asante (2011); Hansen *et al*. (2011) and Rusinga, Chapungu, Moyo, and Stigter, (2014). In particular, Rusinga et al. (2014) found out that 70% of the farmers in Manicaland province in Zimbabwe received climate forecast information from radio.

While the radio can reach many people at once, it is largely a one-way communication channel and does not therefore provide opportunities for the recipients to obtain clarifications and customized guidance from the source of the information. Farmers involved in the study for instance reported that they found it difficult to ask questions or seek for clarifications about the information presented on radio. Others scholars for example Orlove, Roncoli, Kabugo and Majugu (2010) and Ziervogel and Opere, (2010) have observed that climate information providers dominantly use one-way communication channels because they cast themselves as sources of knowledge and they therefore focus on information dissemination and outreach. However, reliance on on-way communication channels such as radio reduces the likelihood of targeted users such as farmers to obtain customized information and technical support which are key in enhancing proper use of the information disseminated (Lemos *et al.*, 2012).

3.5 Reliability of scientific climate forecast information from the farmers' perspective

The essence of providing scientific climatic forecasts is to enable farmers to take advantage of good climatic conditions and minimize losses due to climatic uncertainties. Therefore such climate forecast information should be a true a reflection of the climatic conditions that eventually happen if it is to enable the farmers harness the good climatic conditions and reduce losses when conditions are bad (Gyampoh & Asante, 2011). Table 5 shows farmers' perceptions about the reliability of the scientific climatic forecasts measured in terms of the extent to which such forecasts matched with the actual climatic conditions they purported to forecast.

Results in Table 5 show that, majority of farmers perceived the different types of scientific climatic forecast information to be of very low to low reliability. For instance, about 75% of the farmers who had received information on timing of onset of rains perceived it to have very low to low reliability. These findings about the perceived low reliability of the scientific climate forecast information are consistent with those of Ziervorgel and Opere (2010), Nganzi et al. (2015) and Jost *et al*. (2016). These three studies reported that farmers considered climate forecast information mainly broadcasted on radio as unreliable because it related to large geographical area and yet farming activities are shaped by climatic conditions in specific locations.

Farmers involved in this study alluded to the occurrence of spatial variability of rains in their respective districts and sub-counties. They reported instances where some areas received rain while others within the same sub-counties were dry across the same period. This kind of spatial variability cannot be depicted by the climatic information from UNMA which is presented according to climatological zones consisting of four to 20 districts (UNMA,2017). This is consistent with Ziervogel and Opere (2010) who noted that the scientific climatic forecasts generated by national meteorological agencies are not tailored to farmers' local needs because they are given for regions not for specific localities.

Farmers’ perception about the low reliability of scientific climatic information was also related to the way it was presented to them. According to them, the words used to introduce and present the scientific climate forecast information in the local languages made it seem like 'guesswork' and thus unreliable. This was clearly explained by one female participant during one FGD in Bukalasi sub-county, Bududa district who opined that;

Forecasts of weather conditions on radio are usually introduced as 'eno y'entebereza y'obudde' literary translated as 'this is the tentative guess of the expected weather conditions'. This implies that the providers of the information are not sure about what they are telling us! How do they expect us to plan our daily and seasonal activities based on guesswork? (Women's FGD at Bukalasi Sub-county Headquarters, Bududa District, 4th June 2016). According to Hansen et al. (2011), climatic forecasts are normally presented in probabilistic formats in order to show that there is some level of uncertainty entailed. Such probabilistic formats are however difficult for farmers to comprehend without any guidance. Therefore Hansen et al. (2011) as well as Jiri et al. (2016) suggest that scientific climate forecasts should be accompanied with technical guidance to enable farmers to correctly interpret and use the information.

3.6 Timing of the scientific climate forecast information

The time at which scientific climate forecast information is delivered relative to users' needs is a key attribute that determines its feasibility. Gyampoh and Asante (2011) for instance stressed that delivering the right information at the wrong time is useless since the users may not benefit from it. Interactions with farmers during FGDs revealed that the information was considered to be appropriately timed if it was provided 2-3 weeks prior to the event (e.g. onset of rains, cessation) being forecasted. According the farmers, this time lag allows them to make the necessary field preparations and secure inputs ready for the seasons. Therefore any information that comes earlier than three weeks prior to the event being forecasted was perceived as coming too early while that which comes less than two weeks before the forecasted event was considered to be late. Table 6 shows farmers' perceptions about the timing of the different types of scientific climate information they had received in the previous year (2015).

Results in Table 6 indicate that over 55% of the farmers received the rainfall related information earlier than they expected it while less than 20% of them received it just on time. The deviation of the timing of the information relative to when farmers need it compromises the usefulness of such information to the farmers. For instance, farmers involved in the study revealed that late receipt of information on timing of onset of rain resulted into improper preparations for the season in terms of proper land preparation and acquisition of the needed materials. They also however noted that even when the information on timing of rains came earlier than they needed it, they often prepared too early only to lose their seeds to termites and ants because of overstaying in the dry soil before the rains come. Such experiences have adverse implications on the trust that farmers have towards the subsequent information provided to them.

Agricultural production decisions based scientific climatic forecast scientific information

Seasonal rainfall forecast information is aimed at enabling farmers to take decisions and actions related to preparing for projected climatic conditions. Table 7 shows the types of decisions that farmers took after receiving the different types of scientific rainfall information.

The decisions farmers made varied according to the type of information they had received. More than half of farmers made production decisions when they received climatic scientific information about; (i) the onset of the rain; (ii) amount, intensity and distribution of rain and, (iii) weather forecast for 1-3 days. The popular agricultural production decisions made by the farmers included; preparation of land and planting the appropriate crops immediately to ensure effective utilization of the rains. The results further indicate that about 53% of the farmers decided to observe for indigenous indicators when they received information about timing of onset as a means to verify the likelihood for the onset of the rains.

Despite the importance of the scientific climatic forecast information on onset, amount and intensity of rains about 32% and 45% of the farmers who had received such information did not make any production decisions based on the information. Farmers rarely made agricultural production decisions when they received scientific climatic forecasts on the cessation of the rains and likelihood of landslides. About 74% and 52% of the farmers who had respectively received information about the likelihood of landslides and timing of cessation of rains did not make any production decision based on such information. These findings concur with Ziervogel and Opere (2010), Gyampoh and Asante (2011), Shah, Opiyo, Ngaina, and Speranza (2012) and Nganzi et al. (2015) who also show that majority of the farmers who receive scientific climatic forecast information do not use it to make production decisions.

Farmers mainly attributed their limited use of climatic forecast information in making agricultural production decisions to past experiences with 'wrong' forecasts as one participant from Khabutoola sub-county in Manafwa district stated;

I remember last year (2015) there was information on radio warning us about heavy and prolonged rains. We were advised to prepare for the season by storing food, firewood and repairing roofs and strengthening walls of our houses. Some of us based on the information and did not plant beans and maize and we instead kept the seeds for food. To our surprise, the rains came late and they were not as heavy as we had been warned. We ended up with no harvests for that season because we had believed in the information on radio. (Male participant, Male-based FGD at Kabale Trading Center, Khabutoola Sub-county, Manafwa District, 3rd June 2016

Disregard for scientific rainfall information based on past experiences of wrong forecasts was also documented in Ghana by Gyampoh and Asante (2011) and in Kenya by Shah et al., (2012). Within a rain-fed agriculture context, information about the timing of onset of rains is especially the most critical because it forms the basis for production decisions that largely determine the yield a farmer will obtain in the coming season. According to Cooper et al. (2008) and Rao, Ndegwa, Kizito and Oyoo, (2011), disregard of forecast information on the timing of onset of rains severely compromises the likelihood of a farmer to obtain optimal output if the season turns out to be good. Mubiru, Komutunga, Agona, Apok and Ngara (2012) for example noted that most farmers in Uganda do not attain optimal crop yields because they start tilling land after the onset of rainfall resulting into a mismatch between the timing of favourable moisture conditions and the crop's peak water requirements. Future projections of increased frequency and severity of climatic uncertainties in the foreseeable future imply that ignoring and improper use of climatic forecasts will continue to have adverse impacts. Therefore efforts need to be directed towards boosting and sustaining proper use of climatic forecasts among farmers. The success of such efforts requires that different factors that influence farmers' likelihood to use forecast information are identified and addressed.

3.7 Factors that influence farmers' use of scientific climatic information on timing of onset of rains

For farmers who depend on rainfall to plan their agricultural activities, information on the timing of onset of rains is the most critical as it provides an informed basis for key decisions and actions to fully harness the upcoming season. This section explores the factors that influence farmers' use of scientific climatic information on timing of onset of rains to make agricultural production decisions.

Table 6: Timing of the climate forecast information from the farmers' perspective

Type of information	Number of farmers who accessed information	Percentages of farmers		
		Earlier than when it was needed	*Just on time*	*Later than when it was needed*
Timing of onset of rains	223	62.7	17.5	19.8
Likelihood of landslides	161	56.4	14.9	28.7
Timing of cessation of rains	153	79.3	11.8	8.9
Amount, intensity and distribution of rain over the next 2-3 months	133	55.4	17.4	27.2
Forecast of weather for 1-3 days	80	57.2	7.7	35.1

Table 7. Decisions taken by farmers based on scientific climate forecast information received

Type of production decision	Percentage of farmers using type of information to make production decision				
	Timing of onset of rains *(n=223)*	Timing of cessation of rains *(n=153)*	Amount, intensity & distribution of rain *(n=133)*	Weather forecast for 1- 3 days *(n=80)*	Likelihood of occurrence of Landslides *(n=161)*
Plant immediately	49.2	2.5	38.4	42.1	1.3
Carefully look out for indigenous indicators	52.7	33.2	1.6	33.5	0.7
Preparation of land	40.2	0	25.2	23.5	0
Deciding on types of crops to grow and how to manage them	2.9	16.2	27.2	5.9	0
Purchase of farm inputs	8.7	0	0.8	14.7	0
Work on soil and water conservation structures	0.0	0.0	4.3	0.0	4.3
Deciding on whether and when to store food	0.0	3.9	0.0	0.0	3.0
Delay to plant	0	27.5	3.8	0	4.9
No decision made	*31.6*	*51.8*	*45.2*	*45.6*	*73.9*

Table 8. Factors influencing the use of information on onset of rains

Predictor category	Predictor variables	B	S.E.	Wald	Sig.	Exp(B)
Household characteristics and assets	Jender of the respondent	0.641	0.464	1.904	0.168	1.898
	Age of the respondent	-0.003	0.018	0.029	0.864	0.997
	Highest education level in the household	0.417	0.068	2.971	*0.038***	1.632
	Household size	0.026	0.066	0. 067	0.123	1.014
	Farm size	0.012	0.105	0.014	0.906	1.012
	Off-farm income sources	-0.305	0.232	1.721	0.180	0.356
	Group membership	0.373	0.151	3.153	0.193	1.286
	Radio ownership	0.770	0.666	7.066	*0.008****	5.868
Perceived quality of forecast information	Perceived reliability of information on onset of rains	0.527	0.461	10.981	*0.001****	3.217
	Perceived timing of information on onset of rains	0.416	0.452	4.847	0.035**	1.615
	Constant	0.376	1.265	3.529	.060	1.758

-2loglikelihood= 186.083, Cox and Snell R Square=0.422, Nagelkerke R square= 0.585
**$p<0.05$, ***$p<0.01$

Results in Table 8 indicate that the likelihood for farmers to use information on onset of rains was dependent on; household characteristics, household assets and the perceived quality of climatic information received by the farmer. The only household characteristic that influenced farmers' likelihood to make production decisions based on information about the timing of onset of the rains was education level. The odds ratio (1.632) corresponding to the highest education in the household shows that when the education level in the household increases by one year, the odds to use forecast information on onset of rains are approximately doubled. This result is consistent with past studies for example Debela, Mohammed, Briddle, Corkrey and McNeil (2015) which observed that formal education enhanced farmers' capacity to access and interpret information.

Ownership of radio was perhaps one of the most key predictors of farmers' likelihood to use information on onset of rains as indicated by the positive coefficient and high odds ratio that was significant at 1% (p=0.008). The odds ratio corresponding to radio ownership indicate that the odds to use forecast information on onset of rains of a farmer who owns a radio set were about six times more than those of one without. These results could be due to the fact that radio was the main channel through which scientific climate information was disseminated.

Results indicate that both the perceived reliability and timing of the information on onset of rainfall positively influenced farmers' likelihood of using the information. The influence of perceived reliability on the likelihood to use the information was significant at 1% level of significance (p=0.001) while the one for perceived timing of the information was significant to 5% level of significance (p=0.035). Specifically, the results reveal that a farmer who perceives climatic forecast information to be highly reliable has three times higher odds to use it to make production decisions than one who perceives the information to have low reliability. Similarly, the odds to use forecast information to make production decisions for a farmer who perceives the information to be timely are approximately two times those of one who perceives the information to be inappropriately timed. These findings corroborate with those of Stone and Meinke (2006); Gyampoh and Asante (2011); Lemos et al., (2012); and Mpandeli and Maponya (2013) who observed that farmers were likely to use information if they considered it to be credible, reliable and timely. These findings suggest that efforts to boost farmers' use of scientific climate information should aim at enhancing their perceptions towards such information as well as customizing it to their needs and circumstances.

4.Discussion and Conclusion

Access to information about expected climatic conditions is critical if smallholder farmers are to reduce risks of climatic uncertainties and take advantage of good climatic conditions. Over 80% of the farmers had access to scientific climate information especially on timing of onset and cessation of rains and likelihood of occurrence of landslides. The information was mainly received through radio and rarely from fellow farmers and extension workers. Reliance on radio and limited involvement of extension workers in dissemination of scientific information implied that farmers did not obtain customized guidance in interpreting and applying the information. Farmers perceived scientific information to be of low reliability and inappropriately timed relative to their needs. These perceptions were especially driven by farmers' past experiences of wrong forecasts and the large spatial scale at which the information was presented. The farmers used the information to decide on types of crops to grow, purchase farm inputs as well as decide whether and when to plant appropriate crops for a given season. Over half of the farmers who received scientific climatic information on timing of onset of rain first validated such information by observing indigenous indicators. The likelihood for farmers to use scientific climatic information to make production decisions was enhanced by farmers' education level, ownership of a radio set and the perception that the information was reliable and timely. Thus efforts aimed at enabling farmers to improve and maintain their agricultural production amidst climate uncertainties need to customize climate forecast information to farmers' needs to spur proper widespread use of such information.

Acknowledgements

We acknowledge the funding for this study which was provided by the Norwegian Agency for Development Cooperation (NORAD) through the Regional Capacity Building for Sustainable Natural Resource Management and Agricultural Productivity under Climate Change (CAPSNAC) Project Grant No: UGA 13/0020. We are also grateful to the farmers and agricultural extension workers for their time and information.

References

1. African Green Revolution Alliance [AGRA]. (2014). Africa agriculture status report 2014: Climate change and smallholder agriculture in Sub-Saharan Africa. Nairobi, Kenya.

2. Chang'a L, B., Yanda, P. Z., & Ngana, J. (2010). Indigenous knowledge in seasonal rainfall prediction in Tanzania: A case of the South-western Highland of Tanzania. Journal of Geography and Regional Planning Vol. 3(4), pp. 66-72.

3. Cooper, P. J. M,. Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change? Agriculture, Ecosystems and Environment. 126 (2008), 24–35.

4. Danielsen, S., Karubanga, G., & Mulema, J. (2015). Institutionalization. Listening to the silent patient. Uganda's journey towards institutionalizing inclusive plant health services. Center of Agricultural Bio-Sciences International - CABI working paper 7, doi.org/10.1079/CABIPLANT.37-55

5. Debela, N., Mohammed, C., Bridle, K., Corkrey, R., & McNeil, D. (2015). Perception of climate change and its impact bysmallholders in pastoral/agropastoral systems of Borana, South Ethiopia. SpringerPlus, (2015) 4:236. Doi: 10.1186/s40064-015-1012-9

6. Department of Disaster Preparedness [DDP]. (2012). The 2010–2011 Integrated rainfall variability impacts, needs assessment and drought risk management strategy. Office of the Prime minister, Kampala, Uganda.

7. Deressa, T. T., Hassan, R.M., Ringler, C., Alemu, T., & Yusuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change. Doi:10.1016/j.gloenvcha.2009.01.002.

8. Egeru, A. (2012). Role of indigenous knowledge in climate change adaptation: A case study of Teso sub-region, Eastern Uganda. Indian Journal of Traditional Knowledge, 11(2), 217-224.

9. Egeru, A. (2016). Climate risk management information, sources and responses in a pastoral region in East Africa. Climate Risk Management, 11(2016), 1–14. Available at: http://dx.doi.org/10.1016/j.crm.2015.12.001.

10. Field, A. (2009). Discovering statistics using SPSS. Third Edition. SAGE publications, London, United Kingdom. I

11. Gukurume, S. (2013). Climate change, variability and sustainable agriculture in Zimbabwe's rural communities. Russian Journal of Agricultural and Socio-Economic Sciences, 2(14), 89-100.

12. Gyampoh, B. A., & Asante, W. A., (2011). Mapping and documenting indigenous knowledge in climate change adaptation in Ghana.

13. Hansen, J. W., Mason. S. J., Sun, L., & Tall, A. (2011). Review of seasonal climate forecasting for agriculture in sub-Saharan Africa. Expl Agric, 47 (2), 205–240. Doi: 10.1017/S0014479710000876

14. Hisali, E., Birungi, P., &Buyinza, F. (2011). Adaptation to climate change in Uganda: Evidence from micro level data. Global Environmental Change, 21(2011), 1245–1261. Doi:10.1016/j.gloenvcha.2011.07.005.

15. Inter-governmental Panel on Climate Change [IPCC]. (2014). Climate Change 2014 Synthesis Report. IPCC, Geneva, Switzerland.

16. Jiri, O., Mafongoya, P. L., Mubaya, C., & Mafongoya, O. (2016). Seasonal Climate Prediction and Adaptation Using Indigenous Knowledge Systems in Agriculture Systems in Southern Africa: A Review. Journal of Agricultural Science, 8(5),156-172. Doi:10.5539/jas.v8n5p156.

17. Jost, C., Kyazze, F. B., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., ... Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities.

Climate and Development, 8(2), 133-144. Doi: 10.1080/17565529.2015.1050978.

18. Kaggwa, R., Hogan, R., & Hall, B. (2009). Enhancing the Contribution of Weather, Climate and Climate Change to Growth, Employment and Prosperity. UNDP/NEMA/UNEP Poverty Environment Initiative, Kampala, Uganda.

19. Kibwika, P. (2007). Professional ignorance and non-professional experts: Experiences of how small scale vanilla farmers in Uganda learned to produce for export. Social learning towards a sustainable world. Wageningen Academic Publishers, 25, 449-463.

20. Knapen, A., Kitutu, M. G., Poesen, J., Breugelmans, W., Deckers, J., & Muwanga, A. (2006). Landslides in a densely populated county at the foot slopes of Mount Elgon (Uganda): Characteristics and causal factors. Geomorphology, 73 (2006), 149–165. Doi:10.1016/j.geomorph.2005.07.004.

21. Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and psychological measurement, 30, 607-610.

22. Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. Nature climate change, 2(2012), 789-794. Doi. 10.1038/NCLIMATE1614.

23. Masinde, M., & Bagula, A. (2011). ITIKI: Bridge between African indigenous knowledge and modern science of drought prediction. Knowledge Management for Development Journal, 7(3), 274-290. Available at: http://dx.doi.org/10.1080/19474199.2012.683444.

24. Mbogga, M. S. (2012). Climate profiles and climate change vulnerability assessment for the Mbale region of Uganda. UNDP Consultancy report. Kampala, Uganda.

25. Ministry of Water and Environment [MWE]. (2015). Economic assessment of the impacts of climate change in Uganda. National level assessment: Agricultural sector report. March 2015, Kampala, Uganda.

26. Moeletsi, M. E., Mellaart, E. A. R., Mpandeli, N. S., & Hamandawana, H. (2013). The Use of Rainfall Forecasts as a Decision Guide for Small-scale Farming in Limpopo Province, South Africa. Journal of Agricultural Education and Extension, 19(2), 133-145.

27. Mpandeli, S., & Maponya, P. (2013). The Use of Climate Forecasts Information by Farmers in Limpopo Province, South Africa. Journal of Agricultural Science, 5(2), 47-55. Doi:10.5539/jas.v5n2p47.

28. Mubiru, D. N., Komutunga, E., Agona, A., Apok, A., & Ngara, T. (2012). Characterizing agrometeorological climate risks and uncertainties: Crop production in Uganda. South African Journal of Science. Doi.org/10.4102/sajs. v108i3/4.470.

29. Mugagga, F., Kakembo, V., & Buyinza, M. (2012). Land use changes on the slopes of Mount Elgon and the implications for the occurrence of landslides. Catena, 90(2012), 39–46.

30. Nganzi, P., Kajumba, T. C., Barihaihi, M., Bataze, J., & Mujuni, G. (2015). Use of indigenous knowledge in weather forecasting in Uganda National survey. Africa Climate Change Resilience Alliance (ACCRA), Kampala, Uganda.

31. Okonya, J. S., & Kroschel, J. (2013). Indigenous knowledge of seasonal weather forecasting: A case study in six regions of Uganda. Agricultural Sciences, 4(12), 641-648.

32. Orlove, B., Roncoli, C., Kabugo, M., & Majugu, A. (2010). Indigenous climate knowledge in southern Uganda:the multiple components of a dynamic regional system. Climatic Change,2010(100), 243–265. Doi 10.1007/s10584-009-9586-2.

33. Rao, K. P. C., Ndegwa, W. G., Kizito, K., & Oyoo, A. (2011). Climate variability and change: Farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. Experimental Agriculture, 47, 267–291.

34. Rusinga, O., Chapungu, L., Moyo, P., & Stigter, K. (2014). Perceptions of climate change and adaptation to microclimate change andvariability among smallholder farmers in Mhakwe communal area, Manicaland province, Zimbabwe. Ethiopian Journal of Environmental Studies & Management , 7(3) , 310 – 318. Doi: http://dx.doi.org/10.4314/ejesm.v7i3.11.

35. Shah, P., Opiyo, R., Ngaina, J., & Speranza, C. I. (2012). Options for Improving the Communication of Seasonal Rainfall Forecasts to Smallholder Farmers –The Case of Kenya. German Development Institute Briefing Paper 17/2012.

36. Soropa, G., Gwatibaya, S., Musiyiwa, K., Rusere, F., Mazima, G, A., & Kasasa, P. (2015). Indigenous knowledge systems weather forecasts as a climate change adaptation strategy in smallholder farming systems of Zimbabwe: Case study of Murehwa, Tsholotsho and Chiredzi districts. African Journal of Agricultural Research, 10(10), 1067-1075. Doi: 10.5897/AJAR2013.7205.

37. Stone, R.C., & Meinke, H. (2006). Weather, climate, and farmers: an overview. Meteorol. Appl. (Supplement), (2006), 7–20. Doi:10.1017/S1350482706002519.

38. Sultan, B., Barbier, B., Fortilus, J., Mbaye, S. M., & Leclerc, G. (2010). Estimating the Potential Economic Value of Seasonal Forecasts in West

Africa: A Long-Term Ex-Ante Assessment in Senegal. Weather, climate and society, 2010(2), 69-86. Doi: 10.1175/2009WCAS1022.1.

39. Uganda Bureau of Statistics [UBOS]. (2010). Uganda census of agriculture 2008/2009. Volume III: Agricultural household and holding characteristics report, December 2010, Kampala, Uganda

40. Uganda Bureau of Statistics [UBOS]. (2014). National Population and Housing Census 2014 Provisional Results November 2014: Revised Edition. Kampala, Uganda.

41. Uganda Bureau of Statistics [UBOS]. (2015). 2015 Statistical Abstract. October 2015, Kampala, Uganda.

42. Uganda National Meteorological Authority [UNMA]. (2017). March to May 2017 Seasonal Rainfall Outlook over Uganda. https://www.unma.go.ug/index.php/climate/seasonal-forecasts. Accessed on June 10th 2017.

43. Ziervogel, G.,& Opere, A., (2010). Integrating meteorological and indigenous knowledge-based seasonal climate forecasts in the agricultural sector. International Development Research Centre, Ottawa, Canada. Climate Change Adaptation in Africa learning paper series.