Utilization of Weather and Climate Information for Adaptation Decision-Making among Smallholder Farmers in Gulu, Uganda

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ABSTRACT

Climate change is a major driver of vulnerability among rural smallholder farmers. Vulnerability is exacerbated by a lack of reliable weather and climate information necessary to support farm-level adaptation decision-making. This study assessed utilization of weather and climate information for adoption of climate-smart crop production practices by smallholder farmers in Gulu District of northern Uganda. Specifically, the study determined how access, understanding, and application of weather and climate information influenced adoption of climate-smart crop production practices among the smallholder farmers. Data were collected from a total of 126 respondents using household interviews, Focus Group Discussions, and key informant interviews in three villages. Statistical analysis was done using SPSS (SPSS Version 25, SPSS Inc. USA). Results showed that the majority (55%) of the respondents had access to weather and climate information. Daily forecasts were the most (50%) received by the respondents, followed by seasonal forecasts (30%). The predominant sources of the forecasts in the study area were use of local radio stations (25%) and relying on indigenous knowledge (25%). The study participants utilized weather and climate information mainly for preparing land (39%), and timing of the planting dates (35%). Results of the multinomial logit analysis indicated that utilization of weather and climate information among smallholder farmers who had access to the information increased farmers' adaptability to climate smart crop production practices by 7% ($p = 0.657$, coeff = 144.269). The probability of adoption rises with the increase in household size (98.820; $p = 0.584$) and age (98.820; $p = 0.584$) of the smallholders. Gender of farmers had the least effect of 5% ($p = 0.540$; coeff = -206.496) on the adoption of the climate smart crop production practices. In conclusion, application of weather and climate information on its own may weakly contribute to adoption of climate smart crop production practices. The study recommends that there is a need for the country's Ministry responsible for Agriculture to build the capacity of extension agents to enhance their understanding and subsequently, application of weather and climate information in order to improve adaptive skills in climate-smart agricultural production among the smallholder farmers.

Key words: Adaptation strategies, climate change, smallholder farmers, Uganda, weather and climate information.

INTRODUCTION

Climate change presents a major challenge to agricultural production and rural livelihoods. Frequent and severe climatic shocks due to droughts and floods, for example, threaten farmers' lives and livelihoods, challenging the key role agriculture could play in promoting economic growth, food security, poverty reduction, and community resilience (Kalungu and Leal Filho, 2018). Global climate projections paint a gloom future. Future climate in Sub-Saharan Africa is projected to be hotter with more frequent droughts (Cairns, *et al*., 2012). Average temperature is projected to increase by more than 2°C across the continent by 2050. The projections suggest further shifting in average growing conditions, increase in weather and climate variability, and more uncertainty in predicting tomorrow's weather and climate conditions (World Bank, 2015). These climate risks pose a challenge of developing innovations aimed at improving rural livelihoods and environment conservation. Smallholder farmers are most affected by these climatic changes as their farming activities are highly sensitive and vulnerable to climate change risks. Like many other smallholder farmers in Africa, the smallholders in Gulu have shown evidence in the past of being able to adapt to climatic risks. However, the predicted magnitude and pace of change in climate is unprecedented and will require both progressive and transformative change (Gbegbelegbe, *et al*., 2017).

Providing accurate, reliable, and timely weather and climate information is central to building climate resilience of smallholder farmers. The information forms the fundamental basis upon which many adaptive decisions are made, such as what crops and variety to grow, when to grow, when to harvest, managing risks, and mitigating adverse effects of climate change (FAO, 2015). Such measures may enhance food security by reducing harvest losses, improving social and economic outcomes and increasing livelihood resilience (Ombogoh, *et al*., 2018). Weather and climate information is thus crucial for the provision of early warning to farmers. However, despite the critical role agrometeorological information could play in efforts towards adaptation to climate change among smallholders, utilization of this information has been hampered by a myriad of challenges. Chamboko, *et al.* (2008), indicate existence of limitations in terms of information delivery mechanisms such as reliability, timing, and infrastructural development. Long, *et al.* (2016), reported that over 40% of smallholder farmers cannot understand the weather and climate information disseminated and this perhaps affects the rate of adoption of climate-smart crop production practices. Fonta, *et al*. (2015), on the other hand, explain that a big number of farmers may have access to weather and climate information but tend to vary in how they understand that information provided in terms of rainfall amount and cessation especially smallholder farmers in rural areas. This study assessed utilization of weather and climate information for adoption of climate-smart crop production practices by smallholder farmers, focusing on Gulu District of northern Uganda, as a case study. The study determined how access, understanding, and application of weather and climate information influenced adoption of climate-smart crop production practices among the smallholder farmers.

MATERIALS AND METHODS

Study Area

The study was conducted between September 2017 and January 2018 in the northern District of Gulu (Figure 1). It took place in three villages of Panyikworo, Mede central, and Te-Olam in three sub-counties of Bungatira, Palaro, and Paicho, respectively. Gulu District is bordered by Lamwo District to the north, Pader District to the east, Omoro District to the south, Nwoya District to the southwest, and Amuru District to the west. The district headquarters in the town of Gulu is approximately 340 kilometres by road north of Kampala, Uganda's capital city. The coordinates of the District are 02 45N, 32 00E. The national census conducted in 2014 (UBOS, 2014) put the population at approximately 275,613, with 141,042 females and 134,571 males. The major source for income in the district is agriculture with main emphasis on food crops such as millet, cassava, cow peas, potatoes, beans, simsim and sunflower. Cash crops include cotton, tobacco, sugar cane and simsim. Fishing is mainly practiced on the western end of the district in the River Nile. Customary land holding is the common system of land ownership. The climate of Gulu is characterized by both wet and dry seasons (Gulu District Local Government, 2013). The wet season occurs from April to November, with peaks during the months of May, August, and October. The average total rainfall received is 1,500 mm per annum, with the monthly average ranging from 1.4 mm in January to 230 mm in August. The dry season begins in November through to March. The average maximum temperature is 50^0 C, with a minimum of 18^0 C.

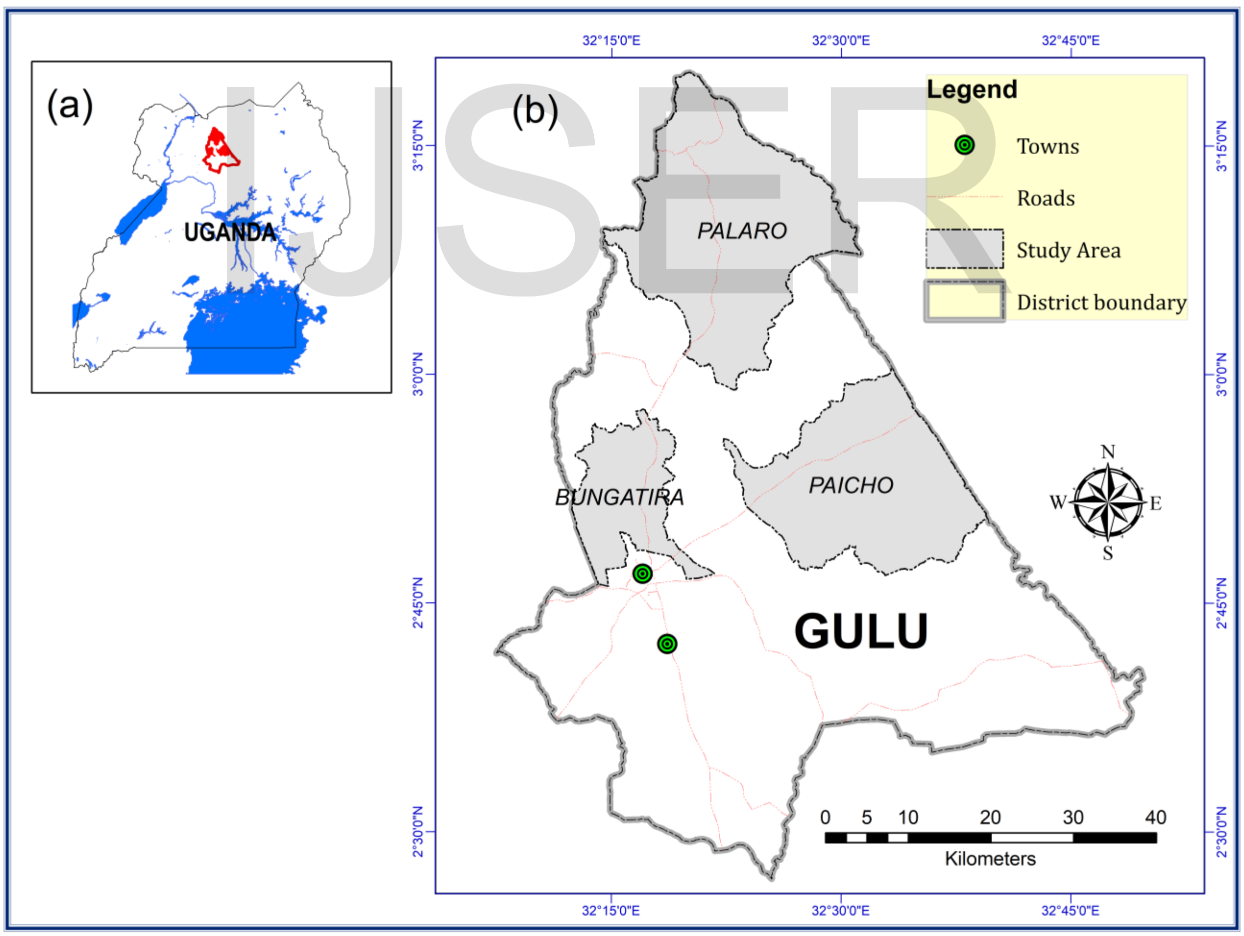


Figure 1. Map of the study area (a - map of Uganda; b - Gulu District showing study sub-counties)

Data Collection
Data were collected from a total of 136 respondents using household interviews (126 respondents) and key informant interviews (10 participants). Focus Group Discussions were conducted with members of nine farmer groups, three from each study village. The three study villages together with farmer groups were purposively selected for the study because they were beneficiaries of development projects in the district promoting the utilization of weather and climate information for farming decisions. Households were randomly sampled, while key informants including lead farmers, local leaders, and extension agents were purposively selected.

Data Analysis
Data from the field were compiled, sorted and checked for completeness. Statistical tests were performed using SPSS software (SPSS Version 25, SPSS Inc. USA). Descriptive statistics, including frequency distributions and percentages were used to summarize respondent characteristics. Correlations using a bivariate Pearson's Rank Correlation were performed to ascertain if there was a relationship between the utilization parameters of access, understanding, and application of weather and climate information. Logistic regression model was used to identify the factors that determined farmers' adoption to climate smart crop production practices. Previous research findings have shown that logit models are the most appropriate econometric models to apply to the evaluation of qualitative dependent variables that have dichotomous groups (i.e. 'adopted' and 'not adopted') while the independent variables are categorical, continuous and dummy (Long and Freese, 2006). The Binary logistic regression (BNL) model has also been used by other authors in order to decipher the factors influencing farmers' adaptation in the face of climate variability and change (Belay, *et al*., 2017). Since the binary regression models suggested that a high percentage of observed adaptability was not as a result of the interaction of any two studied parameters, it was of interest to investigate on the influence of the interactions among the several factors that were included in this study. Among these factors were age, gender, education level, and household size. Multinomial logical regression analysis was therefore performed to determine the factors that influenced the choice of adaptation strategies by the smallholder farmers.

RESULTS AND DISCUSSION

3.1 Demographic Characteristics of Sample Farmers
The demographic characteristics of sample farmers that were studied included gender, age, level of education and household size.

Table 1: Respondents' Profiles

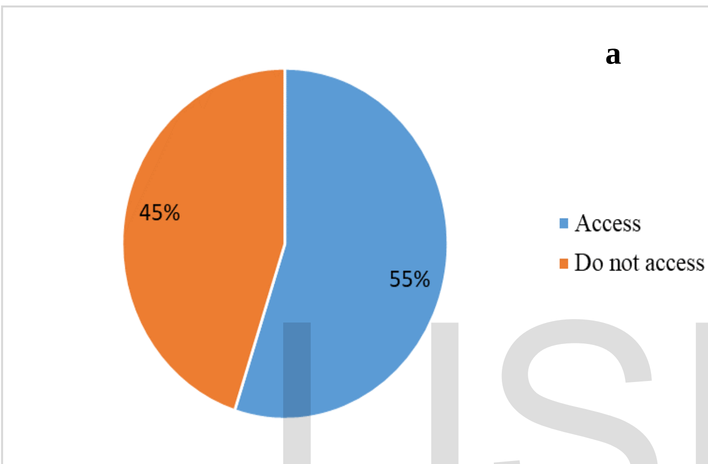
Characteristics	Category	Number (%)
Gender	Male	43 (37.1)
	Female	73 (62.9)
Age	<30 years	18 (15.5)
	30-39 years	30 (25.9)
	40-49 years	43 (37.1)
	>50 years	25 (21.6)
Education Level	Illiterate (zero year in School)	20 (17.2)
	Primary (7 years in school)	54 (46.6)
	Secondary (11-13 years in School)	36 (31.0)
	Certificate	6 (5.2)
Household Size	<5 people	24 (20.7)
	5-7 people	44 (37.9)
	8-10 people	30 (25.9)
	>10 people	18 (15.5)

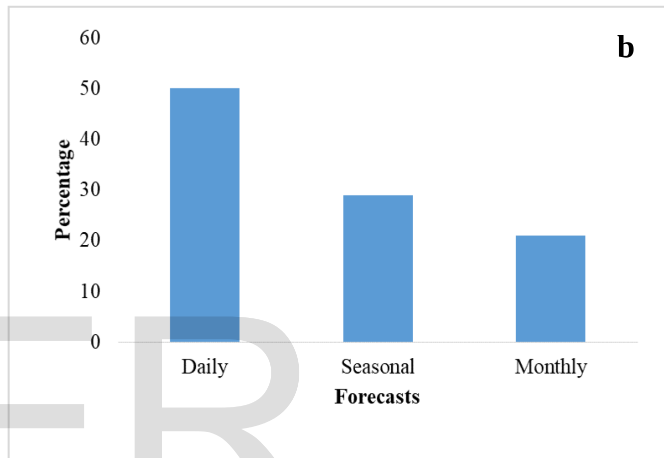
Table 1 above shows that the majority (62.9%) of the study respondents were females, aged between 40 and 49 years (37.1%). Most of the respondents were educated up to primary level (46.8%), with household size of 5-7 individuals (37.9%). Results of level of access showed that the majority (55%) of the respondents had access to weather and climate information, as indicated in Figure 2. Daily forecasts were the most (50%) received type of forecasts by the respondents, followed by seasonal forecasts (30%). Use of local radio stations (25%) and indigenous knowledge (25%) were the predominant sources of forecasts in the study area. Previous studies have reported that farmers' adaptation to climate change is determined by factors such as education, age, farming experience, gender, access to extension, credit, markets, farm income and farm size (Hassan, 2008; Deressa *et al*., 2010; Abid, Scheffran, Schneider, and Elahi, 2019).

Women and men in households and communities have disproportionate levels of access and hence utilization of weather and climate information for farming practices. Women particularly face limited access to information, opportunities to earn income, and power to make decisions about their livelihoods and protecting their families from the impacts of climate change. These constraints may limit the ability of the smallholders to respond to the forecasts. A considerable percentage of the smallholder farming in the rural areas are mostly illiterates. Many studies acknowledge the difficulty illiterate farmers face in accessing, understanding and eventually utilizing the weather and climate information for adaptation decision-making. For example, Antwi-Agyei, *et al*. (2014), reported that the smallholder farmers make little use of the weather and climate information because the channels of communicating the information are not suitable for the illiterate population. In their study, Naab, Abubakari, and Ahmed (2019), indicated that the use of weather and climate information is not only constrained by the lack of it, but also by the inability of potential users to respond to it. An example was documented in Burkina Faso where the absence of basic agricultural technologies made it difficult for farmers to respond to seasonal forecasts (Ingram, *et al*., 2002).

3.2. Access, Types of Forecasts, and Sources of Weather and Climate Information

The level of access, types and sources of weather and climate information were assessed. Results showed that the majority (55%) of the respondents had access to weather and climate information. Daily forecasts were the most (50%) received type of forecasts by the respondents, followed by seasonal forecasts (30%). Use of local radio stations (25%) and indigenous knowledge (25%) were the predominant sources of forecasts in the study area, as indicated in Figure 2.





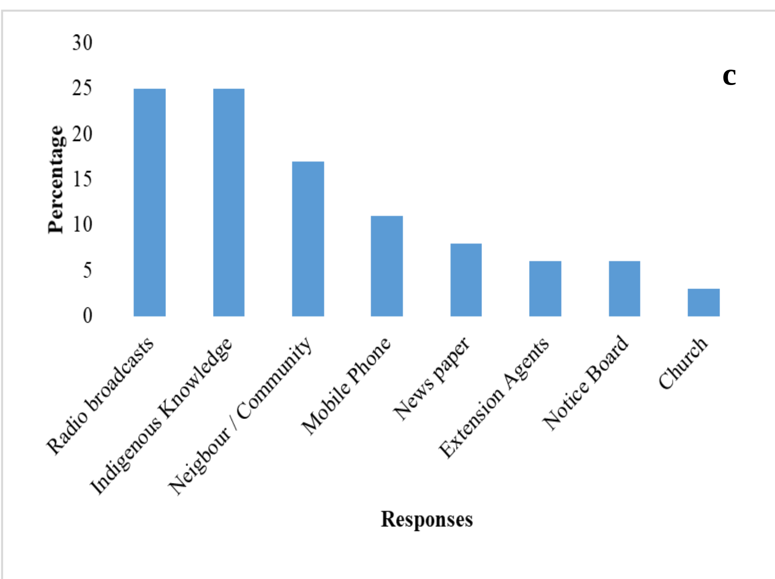


Figure 2. Level of access of forecasts (a), types (b) of forecasts, and sources of weather and climate information (c).

In this study, the results of logistic regression model showed that the probability of adoption rises with the increase in household size and age of the smallholders. Earlier investigations have shown that the visible tendency of larger households to adapt to climate change is probably due to their higher endowment of labor (Oyekale and Oladele, 2012). This implies that larger households have a higher propensity to adapt in the face of climate variability and change than smaller households. Many studies have shown that age of household head has a positive effect on farmers' adaptation decision (Belay, *et al*., 2017). In this study, the results suggest that the older the smallholder farmer, the greater the propensity to adopt climate smart crop production practices, and possibly to climate change in the study area. It is therefore evident that the respondents were of diverse backgrounds and this is likely to cause variation in their decision to adopt new technologies depending on how they perceive the benefits.

3.3 Relationships among Variables

3.3.1 Study Variables

Variables studied to understand the influence of utilization of weather and climate information for adoption of climate-smart crop production practices were assessed. Utilization was measured by three variables including access, understanding, and application. Adoption was measured using timely planting of crops, using improved crop varieties, and timely harvest and post-harvest handling. Each variable was given a code generated using the SPSS software, as indicated in Table 2 below;

Table 2. Definitions of Codes Generated Using SPPS Statistical Package

SPSS Code	Meaning of Statement
1	Communication channels used to disseminate weather and climate information is appropriate in the community
2	One puts in extra effort to seek for weather and climate information services in his/her community
3	The timing of the weather forecasts is suitable for farming activities in the season
4	Access to weather and climate information (average for 1 – 3 above)
5	One is not constrained by the language used in weather forecasts
6	Weather and climate information disseminated is clear and easy to understand
7	One has no difficulty in understanding forecast terminologies
8	Understanding of weather and climate information (average for 5 – 7)

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SPSS Code	Meaning of Statement
9	One is not limited in his/her ability to respond to weather and climate forecasts in terms of assets and options such as ploughs, and new crop varieties
10	Weather and climate information format (packaging) is user-friendly
11	One is able to incorporate specific weather and climate information into farming decision processes
12	Application of weather and climate information (average for 9 -11)
13	One utilizes weather and climate information to guide his/her choice of planting dates
14	Weather and climate information guides one's choice of crop varieties (e.g. drought-tolerant, early maturing, disease-resistant)
15	Harvest and post-harvest handling decisions guided by weather and climate information
16	Adoption of climate smart crop production practices (average of 13 – 15)

3.3.2 Correlation Analysis

Results of correlation analysis are presented in Table 3 below. For each variable, upper values refer to Pearson's correlation coefficient, while the values below indicate the level of significance. The SPSS codes 1-16 are defined as in Table 2.

Table 3. Correlation Analysis Results

Variable	**Access**				**Understanding**				**Application**				**Adaptation strategies**			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Communication Channel (1)	1															
Information seeking behavior(2)	.749**	1														
	.000															
Timing of Forecasts(3)	.563**	.692**	1													
	.000	.000														
Access(4)	.799**	.912**	.858**	1												
	.000	.000	.000													
Language Used(5)	.159	.218*	.276**	.319**	1											
	.089	.019	.003	.000												
Information Clarity(6)	.136	.180	.277**	.309**	.982**	1										
	.146	.053	.003	.001	.000											
Forecast Terminologies(7)	.136	.180	.277**	.309**	.982**	1.000**	1									
	.146	.053	.003	.001	.000	.000										
Understanding(8)	.148	.200*	.278**	.315**	.995**	.996**	.996**	1								
	.114	.031	.003	.001	.000	.000	.000									
Ability to respond(9)	.509**	.208*	.494**	.317**	.080	.061	.061	.071	1							
	.000	.025	.000	.001	.395	.515	.515	.452								
Packaging(10)	-.308**	-.420**	-.150	-.304**	-.012	.024	.024	.006	.281**	1						
	.001	.000	.108	.001	.897	.798	.798	.947	.002							
User Friendliness (11)	.482**	.163	.264**	.173	-.150	-.175	-.175	-.163	.839**	.408**	1					
	.000	.080	.004	.063	.109	.060	.060	.080	.000	.000						

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Application(12)	.043	-.195*	.149	-.054	.033	.049	.049	.041	.723**	.866**	.731**	1				
	.647	.036	.111	.565	.727	.601	.601	.660	.000	.000	.000					
Timely planting(13)	.063	.208*	.485**	.344**	.241**	.252**	.252**	.248**	.192*	-.136	-.153	.002	1			
	.498	.025	.000	.000	.009	.006	.006	.007	.039	.145	.101	.984				
Use of improved crop varieties(14)	.357**	.193*	-.039	.024	-.484**	-.543**	-.543**	-.517**	.283**	-.031	.619**	.125	-.443**	1		
	.000	.038	.681	.796	.000	.000	.000	.000	.002	.743	.000	.181	.000			
Harvest and Post-harvesting handling(15)	-.403**	-.169	.151	-.042	.254**	.250**	.250**	.253**	-.079	.167	-.399**	.079	.786**	-.651**	1	
	.000	.070	.105	.653	.006	.007	.007	.006	.400	.074	.000	.399	.000	.000		
Adaptation strategies(16)	-.244**	-.068	.168	-.036	-.053	-.106	-.106	-.080	.123	.195*	-.029	.204*	.679**	-.055	.794**	1
	.008	.471	.071	.701	.571	.258	.258	.392	.190	.036	.755	.028	.000	.555	.000	

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Table 3 above indicates a weak (r = 0.204, p = 0.028) positive significant linear relationship between application of weather and climate information and adaptation strategies for climate-smart crop production practices.

3.3.3 Logistic Regression Model

Results of logistic regression model indicated that application of weather and climate information was positive and significantly (p = 0.000; coeff =.469) related to smallholder farmers' decision to adopt climate-smart crop production practices. The probability of adoption rose with increase in the household size (p = 0.066, coeff = 0.251) and education level (p = 0.226, -0.291), as shown in Table 4 below.

Table 4. Results of Logistic Regression Model

Variable	Coefficient	Standard Error	Sig.
Gender	-.065	.034	.487
Age	.251	.075	.066
Education Level	-.291	.076	.226
Household Size	.500	.067	.066
Application	.469*	.062	.000

3.3.4 Multinomial Logistic Regression Model

Table 5 indicates that application of weather and climate information increases farmers' adaptability to climate smart crop production practices by 7% (p = 0.657, coeff = 144.269). Gender of farmers had the least effect of 5% (p = 0.540; coeff = -206.496) on the adoption of the climate smart crop production practices.

Table 5. Results of Multinomial Logistic Regression Model

Variable	B	Std. Error	Wald	Sig.
Gender	-206.496	336.606	0.376	0.540
Age	5.484	65.676	0.007	0.933
Education level	-0.881	4.340	0.041	0.839
Household size	98.820	180.675	0.299	0.584
Application	144.269	324.944	0.197	0.657

The study by Zinyengere *et al*. (2013) reported that farmers utilize weather and climate information to plan for planting date of crops. When farmers have access to improved seeds and agrometeorological forecasts, they choose the cultivar that can maximize their return. Patt *et al*. (2005) estimated that 40% of farmers changed the crop variety in response to agrometeorological information in Zimbabwe. When farmers have the information that the season will be wet (or dry) and about the starting of rains they choose long or short maturing cultivars, respectively. Focus Group Discussions indicated that farmers utilized weather and climate information mainly for preparing land (39%), and timing of the planting dates (35%). Focus Group Discussions further revealed that most of the participants did not utilize the information in making farming decisions since they did not understand the information disseminated.

Moser (2014) reported that the language, terminology, as well as how the information is packaged is cited as a key barrier to the use of weather and climate information in farming decisions. More specifically, weather and climate information communicated through radios, in which the information is translated and communicated in local languages and dialects, using local metaphors and examples, and using entertaining communication modes such as music, catchy songs, drama or games to attract listeners, has been shown to enable better understanding, learning and help listeners to easily relate with the communicated information (Bisht and Ahluwalia, 2014). Zinyengere, *et al*. (2013) indicated that the change of planting or sowing date is also a commonly used strategy by farmers when the packaging of weather and climate information is user-friendly. The announcement of the onset of rains helps farmers to decide when to sow and thereby avoid plants suffering from moisture stress during the initial and critical phases. Patt *et al*. (2005) found that 50% of farmers changed the sowing period in response to forecasts. However, Zinyengere *et al*. (2013) found that the change of planting date did not have significant effect on maize yield under poor fertility conditions.

Utilization of mobile phone and internet for weather and climate information are still emerging concepts in developing countries, Uganda inclusive, and therefore have not attracted much patronage. Calanca *et al*. (2011) are of the view that farmers could effectively use the mobile phone for weather and climate information access if the information is sent in the language and format they understand. This could promote easy understanding and appropriate adoption. In conclusion, the study findings indicated that there were few smallholder farmers in Gulu District who utilize weather and climate information for farming decisions, and this may explain the low level of adoption of climate-smart crop production practices.

CONCLUSION AND RECOMMENDATIONS

Results of the multinomial logistic regression revealed that a farmer who applies weather and climate information for farming decisions ($p = 0.657$, coeff = 144.269) increases his or her adaptability to climate smart crop production practices by 7% compared to those who weakly or do not utilize the information. There is therefore a need for the Ministry of Agriculture and Uganda's Meteorological Department to work together to build the capacity of extension agents in the effective use of the weather and climate information in order to improve adaptive skills in among smallholder farmers.

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