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Understanding Small-Scale Farmers' Perception and Adaption Strategies to Climate Change Impacts: Evidence from Two Agro-Ecological Zones Bordering National Parks of Uganda

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Abstract

Agricultural production by small-scale farmers in Uganda is vulnerable to climate change because the agricultural regime is rainfed and subject to climatic changes and variability with significant impact on agricultural productivity, livelihoods and food security. This study analysed small-scale farmers perceptions and impacts of climate change on agricultural production and livelihoods and adaptation options to tackle the adverse effects of climatic changes in Karenga (lowland agroecology) and Kapchesombe (highland agroecology). Both study areas are adjacent to Kidepo Valley and Mount Elgon National Parks respectively. Analysed by using data obtained from 607 households, (41.5 percent males and 58.5 percent females) and were multistaged and purposively sampled. The study found out that that the small-scale farmers were aware of climate change events. Meteorological data analysed confirmed the warming. The largest proportion of the respondents was affected by climate change effects with more impacts felt in Kapchesombe (highland agroecology). The major coping strategies employed include: planting different crops, different planting dates, different crop varieties, soil conservation and crop diversification. Coping strategies employed to contain extreme weather events included terracing, tree-planting, digging drainage channels, planting cover crops, and food storage and meals regulations. Other challenges associated with climate change included: food insecurity due to crop failure, soil erosion, shift in spread of diseases and land degradation. Government should provide effective and productive agronomic farm inputs and production assets and working farm-to-farm extension programme so as to build the adaptive capacity of the vulnerable and improve agricultural production. This should be intertwined with relevant traditional methods.

Keywords: climatic variability, small-scale farmer, adaptation, national parks

1. Introduction

Climate change and variability is an impediment to development and affects agricultural production, food security and livelihoods in sub-Saharan Africa due to rain-dependent agricultural production system (Deressa et al., 2010; Nhemachena et al., 2008). Agricultural production in Uganda is vulnerable to climate change because the agricultural regime is rainfed and subject to climatic changes and variability which are now frequent affecting agricultural productivity, leaving rural communities livelihoods and food insecure (Okonya et al., 2013). Agriculture has for long been the cornerstone of Uganda's economy in terms of contribution to the country's domestic product (GDP). For instance, it comprises of about 23.7 percent of the total GDP, employs about 73.0 percent of the labour force, and accounts for 47.0 percent of the country's total export (NDP, 2010). According to Okonya et al. (2013) and Hepworth (2010), the agricultural sector is dominated by small-scale farmers of mixed crop and livestock production with low productivity undermined by traditional farming practices such as lack of soil and water conservation practices, poor complimentary services such as farm-to-farm extension services and occurrence of extreme weather events such as prolonged drought, flash-floods and soil erosion. The current study postulates that these factors could undermine the adaptive capacity of the small-scale farmers and hence increase their vulnerability to the adverse effects of climate change.

Global changes inform of global warming and climatic variability has threatened the development trajectory in the least developed countries with greatest impacts in the sub Saharan Africa and Uganda is not exclusive (Asiimwe, 2007; GoU, 2007; IPCC, 2014). Arguably climate change is impacting on a broad facets of life: health, agriculture, environment, water resources and fisheries, because of overreliance on the rainfall variable for most of the agro-based livelihoods (Cooper et al., 2008). Climatic models for Uganda have shown that the country experiences high variability and high temperatures and reduced rainfall and increased rainfall variability reduces crop yield and threaten food security and livelihoods (NDP, 2010; Hepworth, 2010). The effects of climatic shocks and extreme weather events take toll on the small-scale farmers and the fact that climate has changed in the past and will continue to change in the future underlines the need to understand how farmers perceive and adapt to climatic change impacts to guide future coping strategies to minimize the negative impacts (Hepworth and Goulden (2008). In Uganda for instance, studies have shown that much of the country's agricultural production is rain-fed, meaning that changes in weather conditions have important implications for households' total agricultural production and well-being (Asiimwe & Mpuga, 2007; Republic of Uganda, 2006). In line with structural transformations in the economy, the agricultural output as a share of the total GDP has declined over the years due to poor traditional practices that are dependent on natural weather patterns, so that variations in precipitation amounts results in large variations in total output and farm incomes for the small-scale farmers who are not well-endowed with resources and with low adaptive capacities. This volatility output due to climatic variability and extreme weather events could mean a large burden for low-income small-scale farmers unable to acquire adaptation technology and many times lacking farm-level extension services support, credit and insurance services and critical agronomic inputs (Okonya et al., 2013; Asiimwe & Mpuga, 2007). Parry et al. (1999) also noted that climatic changes and variability directly affects agricultural production given that the sector is sensitive to climatic changes and precipitation variability and therefore making small-scale farmers vulnerable. As Orindi et al. (2005) observes, Uganda is vulnerable to climatic changes and variability and this situation could amplify and worsen food security, households' poverty, and poor health given the projections of warming temperature for the county.

Climate change is unquestionably a natural process, however, significantly affected by human induced activities (Deressa et al., 2010). This study postulates that climate is changing, and given that it has in the past, and will continue in the future, therefore underpins the urge to understand how the small-scale farmers' perception is and adapt to adverse effects of climate change in areas near protected areas (national parks) in Eastern and North Eastern Uganda.

Studies have shown that African farmers have perceived and responded differently to tackle the adverse effects of climatic changes and rainfall variability in Tanzania, South Africa, Ethiopia, Ghana, and Uganda (Komba et al., 2012; Maponya et al., 2012; Tafesse et al., 2013; Fosu-Mensah et al., 2010; Okonya et al., 2013). However, none of these illustrates responses from small-scale farmers in areas adjacent to national parks and the conservation implications. The small-scale farmers in Karenga and Kapchesombe put a lot of emphasis on agricultural production, but climate change could adversely impact on their agricultural production and understanding their perception of and adaptation strategies is critical to help farmers in overcoming adaptation challenges.

Further, a variety of coping strategies have been put forward by various studies which include: planting different crop varieties, changing land size, irrigation, crop diversification and changing from farming to non-farming strategies (Okonya et al., 2013; Maponya et al., 2012; Deressa et al., 2010; Fosu-Mensah et al., 2010; Okoye, 1998). Though informative, except for Okonya et al. (2013), these cases are not in Uganda and are at national or regional level in scope yet effects of adverse climatic changes are at local level and require area-specific adaptations based on ground factors.

Literature shows that most of the studies on climate change impacts have been at continental, regional and national levels (Okonya et al., 2013; Maponya et al., 2013; Nhemachena et al., 2008; Kurukulasuriya et al., 2000a; Kandlinkar et al., 2000). This study postulates that climate change effects differs from one country to another and from one area to another and therefore adaptation will not be uniform rather area-specific. This study is different from other studies in that we examined the actual adaptation strategies undertaken by the small-scale farmers in Karenga (lowland) and Kapchesombe (highland) both areas being adjacent to Kidepo Valley and Mount Elgon National parks respectively. We contend that this had conservation implications.

Some attempt has been made to analyse how farmers adapt to climate change (Maponya & Mpandeli, 2012; Okonya et al., 2013; Asiimwe & Mpuga, 2007; Deressa et al., 2010). For instance, Maponya and Mpandeli (2012) attempted to understand how farmers adapt to climate change in Limpopo, South Africa but did so among commercial large scale farming community that has access to essential adaptive technology and agronomic inputs. Okonya et al. (2013) analysed farmers' perception of and coping strategies to climate change at national level. Though informative, the study was restricted to potato farmers throughout Uganda and failed to address adaptation and coping strategies challenges by small-scale farmers in areas adjacent to national parks. Asiimwe and Mpuga (2007) looked at rainfall shocks for households' income and consumption in Uganda in general and failed to analyse perception of farmers to climate change in rural areas. Hepworth (2010) reviewed climate change vulnerability and adaptation preparedness in Uganda, though informative, it failed to address the perception of and adaptation to climatic changes and variability for it was a content review of the national adaptation strategy. Despite being highly variable in climatic changes, with extreme climatic shocks like floods, drought and extreme rainfall (NDP, 2010; Hepworth, 2010; Okonya et al., 2013), farm-level studies in areas adjacent to national parks on how the small-scale farmers perceive climate change and how they are responding to climate change impacts are limited. There is also limited knowledge on whether small-scale farmers perceive climate change and how they are coping with it in areas bordering national parks in Uganda. Perceptions of poverty stricken, non-equipped with adaptive technology and resource-constrained small-scale farmers in Karenga, and Kapchesombe lowland and highland agro-ecological zones near Kidepo Valley and Mount Elgon National Parks respectively are not documented. The conservation and policy implications of all this is still grey. Fussel (2007) and Deressa et al. (2009) argued that adaptation should be emphasised because human activities already have affected climate and it will take a while for mitigation measures to yield results. This study argues that understanding farmers' perception is critical in directing future adaptation efforts in addressing adverse climate change impacts in the studied communities because adaptation should be area specific.

This study postulates that, understanding farmers' perception and adaptation strategies gives insight in guiding and supporting them in adopting relevant coping strategies that are site-specific in areas adjacent to the national parks. The study investigated how the small-scale farmers in the two agroecologies in areas bordering Kidepo Valley and Mount Elgon National Parks in Uganda perceived effects of changes in climatic variables on the agricultural production and how they have adjusted coping strategies to effects of climatic changes. It investigated how changes in climatic variables affected crop production in the two agro-ecological zones and how farmers are addressing climate change challenges. We hypothesised that perception of and adaptation to climatic changes is highly influenced by the socioeconomic and demographic factors, and the study is based on plausible methodological approach to studying perceptions of small-scale farmers based on comparing farm survey with data records from the meteorological stations (Thomas et al., 2007), adopted for it being informative in understanding levels of awareness and perception of the small-scale farmers. It also examined factors that influence perception and adaptation strategies. It also offered opportunity for the validation of farmers' claims on climate change and the meteorological data is used to confirm that. Combining perception, meteorological climatic trends, agricultural (crop) production regressed against rainfall data and farmers coping strategies to climate change effects demonstrates the cause-effect relationship and set this study apart.

2. Materials and Methods

2.1 Survey Design and Study Area

Both qualitative and quantitative methods of data collection were employed in households' survey questionnaire whereby 607 questionnaires were administered to respondents. The questionnaire was structured and and thematic with sections on socio-economic and demographic characteristics, perceptions of and adaptation to climatic change impacts. Impacts on agricultural production, income and relationship between climatic variables (rainfall) and crop production was assessed. In-depth interviews were administered for focuss group after household surveys interviews with the small-scale farmers. The standard structured questionnaires were pretested on ten households in Karenga, Kaabong district and adjusted to capture data during the study. Data (rainfall and temperature) from the Department of the Meteorology was obtained and analysed and formed the basis for confirming the basis of small-scale farmers perception and claims on changes in climatic variables. Data on agricultural production was obtained from Ministry of Agriculture, Animal Industry and Fisheries and regressed against rainfall data and this formed the basis for comparing the rainfall variability effects on crop production and food security and comparison with claims by the small-scale farmers.

Clearance was sought from relevant authorities and interviews were conducted in Karenga and Kapchesombe subcounties between January to June 2014. Representative sample of 622 households were interviewed in age range of 15-60+ years and 15 questionnaires were nullified due to error in data capture and only 607 questionnaires were valid and formed the unit of analysis. By gender, males were 41.5 percent and female 58.5 percent. The research assistants were first trained in data capture techniques before commencement of interviews administration. In this study, multi-stage and purposive sampling techniques were employed to select the respondents given the scope of the study involved Eastern and Northeastern Uganda. In the first stage, eastern Uganda was stratified into two agro-ecological zones that are lowland and highland for Karenga and

Kapchesombe respectively. In the second stage, Karenga and Kapchesombe were purposely selected for bordering the national parks. In the third stage, the study areas were stratified using administrative parishes and in the fourth stage, the households were purposively sampled for being small-scale farmers.

Table 1. Agroecological zones (AEZ) and characteristics of Karenga and Kapchesombe study areas

Sn.	*Agroecological zones*	*Characteristics*	*Agricultural practices*
1	Eastern highlands (Kapchorwa district)	Covering the ranges of mt. Elgon, rainfall over 1400 mm; 1300-3600m asl; with rich volcanic soil	Rainfed mixed farming involving mostly stall-fed cattle, small ruminants, vegetable production, cereals such as barley and wheat in Kapchorwa, and Arabica coffee
2	Karamoja wet zone	Northeastern; mostly bordering Acholi, Teso, Kapchorwa and Lango sub regions; reliable rainfall; average rainfall of 1100mm; altitude at 970-1420m asl; moderately good soil	Limited livestock raring; crop cultivation predominant; rainfed consisting of sorghum, millet, early maturing maize, sweet potato, some beans, groundnut and pigeon pea production

Source: http://www.fao.org/agriculture/seed/cropcalendar/aezone.do?iscode=UGA

2.1 Statistical Analysis

Data was coded and entered using MS Excel and analysed by the statistical package for social sciences (SPSS) version (13.0) and later exported to STATA (version 10.0) for multinomial logit regression analysis together with Chi-squared and t-test as the major statistical tools employed to analyse small-scale farmers perception and adaptation strategies to tackle adverse effects of climate change. Linear regression was used to analyse trend in climatic variables (temperature and rainfall) to establish change in climatic variables.

2.2 Analytical Methods

The common approach to studying perception of farmers to climate change in developing countries in Africa is based on comparing farm survey or farm group discussion results with data records from meteorological stations (Deressa et al., 2010; Thomas et al., 2007); and is informative approach in terms of understanding the level of awareness of the small-scale farmers and the validation of farmers claims. Previous studies (Deressa et al., 2010; Nhemachena & Hassan, 2007) found out that perception and coping strategies to climate change are influenced by socioeconomic and environmental factors. We therefore hypothesised that factors which affect perception and the development of adaptation strategies include gender of the respondent, the agroecological location, age, education, years of stay in the community, family size asset value and main source of income.

Seasonal variations in weather (precipitation, humidity and temperature) by standardization of seasonal and annual weather data helps in the determination of the climate change variability and trend to give picture of the behaviour of rainfall and temperature in comparison with the 30 years climatological period under review and is determined by:

$$Y = MX + C \tag{1}$$

Where, M is the gradient and takes the value of negative or positive; When M is negative this shows that the trend is declining and when M is positive, the trend is increasing; R^2 indicates the statistical significance of the trend process. Significance is great from 50% or more ($R^2 \geq 0.5$) and significance is less from below 50% ($R^2 \leq 0.5$); Y = the y axis and X is the x axis of the trend graph.

2.3 Dependent and Independent Variables

In this study, the independent variables were climatic attributes (rainfall and temperature) and factors that influence perception and adaptation (gender, agroecological area, age, education, year in community, family size, assets, and source of income). The dependent variables were effects of climate change (whether a small-scale farmer has or not perceived climate change, whether a farmer has or not developed coping strategies to adverse effects of climate change).

3. Results

3.1 Small-Scale Farmers Perception on Long Term Changes in Climatic Variables

In this study, climatic variables examined are the long-term temperature, rainfall and the occurrence of weather shocks and extreme events in the past ten to twenty years as experienced by small-scale farmers. In Table 2, albeit the largest proportion of farmers in the two sub counties perceived seasonal changes in rainfall amounts and timings, significant changes in rainfall were more reported by farmers in Kapchesombe (97.7%) than Karenga where 66 percent of the respondents observed this change. In relation to temperatures, over 50 and 90 percent of farmers in Karenga and Kapchesombe respectively perceived seasonal changes in temperature. This means that there were changes in temperature and this could have implications for agricultural production. The observed differences were statistically significant at 0.05 level of significance (Table 2). The general perception however, was, that more rainfall was received in the past ten years (Table 3) and this is consistent with NDP (2010) and Hepworth (2010) that stated that eastern Africa including Uganda will experience extreme weather events including high amounts of rainfall, in spite of the precipitation variability in the past years.

Table 2. Seasonal rainfall and climate change variability for Karenga and Kapchesombe subcounties

Variable		Karenga (n=303)	Kapchesombe (n=304)	**Chi-square**	**p-value**
Level of seasonal change in rainfall over the past 10 years	Seasonal change	66.12%	97.7%		
	No seasonal change	15.79%	1.65%		
	Altered seasonal change	16.45%	0.66%	102.35	.000
	Do not know	1.64%	0%		
Level of seasonal change in temperature over the past 10 years	Seasonal change	50.99%	90.1%		
	No seasonal change	14.8%	4.62%	113.8	.000
	Altered seasonal change	32.24%	5.28%		
	Do not know	1.97%	0%		

Table 3. Perception on seasonal rainfall variability in the area over the past 10 years

Variable	**Frequency**	**Percentage**
Rainfall change	566	93.7%
Longer rainy season	298	49.3%
Shorter rainy season	280	46.4%
More rains	346	57.3%
Longer dry spells	244	40.4%
Shorter dry spells	364	60.3%
More dry spells	166	27.5%

3.2 Relationship between Socio-Economic and Demographic Factors and Adaptation to Climate Change

The empirical adoption literature variously point out relationships between socio-economic and demographic factors and adaptation to climate change (Tafesse et al., 2013; Nhemachena et al., 2008). The influence some of the factors have mixed results in literature. Factors considered influential in perception and adaptation were gender, age, education, years of stay in community, family size, assets and main sources of income and were analysed at bivariate level to determine the level of adaptation to climate change.

Looking at gender, although the highest proportion of male (79.2%) and female (70.9%) farmers have been able to address the challenges of climate change, the result of chi-square ($X^2 = 4.999$) show significant differences ($p < 0.05$) in the level of adaptation between male and female which suggests that male farmers are more likely to adapt to climate change than their female counterparts. This could be attributed to male dominance of the society in Karenga and Kapchesombe whereby the male are favoured in terms of land ownership, access to loans, credit and agricultural inputs such as agro-chemicals, fertilizers and extension services. This undermines the central role of women as the sole providers of bread to feed the family. With more climate change impacts and in disadvantageous position, they will take longer time to look for food to feed the family since they do not control production assets.

The influence of age on perception and adaptation to climate change can have mixed influence on perception and adoption of adaptation strategies (Maponya & Mpandeli, 2013; Bekele et al., 2003). In this study, the findings in Table 4 revealed that age is a highly significant factor ($p < .05$) in explaining farmers' adaptation to climate change. There was more likelihood of adaptation by small-scale farmers in the age bracket of 15-44 years. This could be attributed to the fact that whereas the old have the experience, the young with education and better information have better planning ability and horizon to take agricultural production step further than their 'parents' did in the olden days to make living and ends meet and address climate change challenges. An adventurous age bracket, they could also venture in long-term initiatives and measures that previously were seldom used such as agricultural practices aimed at water and soil conservation, livestock farming and off-farm enterprises as best adaptation and/or coping strategies. This finding is consistent with Maponya and Mpandeli (2013).

Studies (Tizale, 2007; Anley et al., 2006) show that improving education and dissemination of knowledge is an important policy measure for stimulating local participation in various development and natural resources management initiative. This study hypothesized that educational level would positively influence adaptation to climate change. Analysis of influence of education revealed that, higher level of adaptation was observed among the small-scale farmers with higher levels of education and the effect of this relationship was statistically significant at 1 percent level. Consistent with Tizale (2007) and Anley et al. (2007), this result indicates that better education improves awareness and information on conservation agriculture and better coping strategies to climate change challenges, and adoption of better techniques, technologies and willingness to do better and embrace new ideas and changes necessary for adaptation. Education also encourages willingness to learn and adopt new ideas and need to excel in whatever one does and in this case in climate-smart agricultural production.

Farming experience is accumulated over years and experienced farmers are expected to have rich knowledge in adaptation and would have participated in modernization effort in tackling climate change. It was hypothesized that those years of stay in community affected and influenced perception and adaptation positively. The result of this study revealed that the duration of stay in years in community was significant ($X^2 = 26.070$; $p = .000$) factor associated with adaptation to climate change, whereby, those with a farming experience of less than 40 years adapted more than those aged forty years and above. This is disturbing and not consistent with Nhemachena et al. (2009) because, year of stay in community should have enabled and equipped farmers with better experience and farming skills and therefore better adaptation. However, one could not discount the fact that at old age, the effect of 'diminishing' returns sets in as effectiveness and efficiency decrease with advanced age. But also, beyond 30 years in farming, possibly farming is not passion any more in ones' life and the zeal for new ventures retardation sets in.

Studies in support (Yirga et al., 1996) of large family size labour pool diverted to off-farm activities as adaptation strategy is discounted by a different school of thought that does not believe that large family size is no adaptation strategy (Tafesse et al., 2013). In this study, it was postulated that family size had great bearing on perception and adaptation. However, the results of the chi-square test were contrary to the apriori expectation. According to the results of the statistical test, family size was found to have no significant ($.086 > .05$) influence on adaptation to climate change. This revelation is disturbing but it could mean that, modern farming geared to tackling climate change effect is not associated with family size but access to adaptation technology. The finding is sharp contrast with with Yirga et al. (1996) and Legas et al. (2006) who argued that family size was a proxy to labour availability and could influence the adaptation of new technology positively. Given the education modernization policy, in Uganda universal primary, secondary education and quota system offers opportunity for all school going children to acquire education up to tertiary level as requirement and therefore family size proxy for labour may not necessarily count in the study areas.

In similar vein, analysis for relationship between asset value and adaptation revealed that family asset had no significant ($X^2 = 4.385$; p value $0.112 > .05$) influence on adaptation to climate change. This may be so because; the study looked at household assets as opposed to farm assets. Farm assets are part of production assets with more relevance in tackling climate change effects.

Regarding main sources of income and adaptation to climate change, this variable was found to be statistically significant ($p = .000$). In particular, the level of adaptation for small-scale farmers who were dependent on farming only was 72.3%; whereas homesteads with off-farm income had 80.0%. Those that practiced mixed crop and livestock farming had 80.2%. The result suggests that being dependent on farming only does not reduce adaptation to climate change. Broadening income base by taking on strategies that include farming and off-farming ventures are effective climate change coping strategies.

Table 4. Relationship between socio economic and demographic factors and adaptation to climate change

Variable	**Response**	*Whether the respondent has been able to address challenges of climate change*				Chi-square	p-value
		No		**Yes**			
		Frequency	Row %	Frequency	Row %		
Gender of respondent	Male	50	20.8%	190	79.2%	4.999	.025
	Female	98	29.1%	239	70.9%		
Total		148	25.6%	429	74.4%		
Sub county	Karenga	122	41.6%	171	58.4%	79.793	.000
	Kapchesombe	26	9.2%	258	90.8%		
Total		148	25.6%	429	74.4%		
Age of small scale farmers	15-24	14	20.3%	55	79.7%	11.899	.018
	25-34	30	19.2%	126	80.8%		
	35-44	33	24.3%	103	75.7%		
	45-54	41	36.3%	72	63.7%		
	> 55	30	29.1%	73	70.9%		
Total		148	25.6%	429	74.4%		
Formal education level	No education	104	31.1%	230	68.9%	15.274	.002
	Primary	29	22.1%	102	77.9%		
	Secondary	11	12.2%	79	87.8%		
	Tertiary	4	18.2%	18	81.8%		
Total		148	25.6%	429	74.4%		
Years stayed in the community	< 10 years	13	11.9%	96	88.1%	26.070	.000
	10-19 years	25	25.3%	74	74.7%		
	20-29 years	28	21.1%	105	78.9%		
	30-39 years	30	27.3%	80	72.7%		
	40 years	49	40.2%	73	59.8%		
Total		145	25.3%	428	74.7%		
Family size	1-4	21	19.3%	88	80.7%	6.592	.086
	5-9	101	29.7%	239	70.3%		
	10-14	25	21.7%	90	78.3%		
	>14	1	14.3%	6	85.7%		
Total		148	25.9%	423	74.1%		
Asset value (UGX shillings)	< 50000/=	26	16.3%	134	83.8%	4.383	.112
	50000-100,000/=	21	24.4%	65	75.6%		
	100,001-150,000/=	10	34.5%	19	65.5%		
	>150,000/=	22	25.0%	66	75.0%		
Total		79	21.8%	284	78.2%		
Main source of income	Farming	64	27.7%	167	72.3%	79.793	.000
	Off-farm income	1	20.0%	4	80.0%		
	Mixed crop & livestock	53	19.8%	215	80.2%		
Total		118	23.4%	386	76.6%		

3.3 Analysis of Climatic Variables: Data from Department of Meteorology

3.3.1 Seasonal Precipitation Trend

Analysis of data obtained from the department of meteorology aimed at understanding the evolution and changes in rainfall and temperature patterns and seasonal changes both within and between seasons across years, decades and the two agroecological zones of Karenga and Kapchesombe. Results indicate that mean rainfall for Kotido (Karenga) is 276.5 mm per annum mostly received between July to October and is unimodal and therefore not well balanced distribution and this has agricultural implications in seasons' calendar for crop cultivation. Rainfall received for Kapchorwa (Kapchesombe) is 1052.9 mm per annum and well distributed throughout the year, with two seasons and favourable for crop production.

The rainfall trend standardisation for Kotido shows very slight increase coming in August to October giving a limited period for crop production as the seasonal calendar is short.

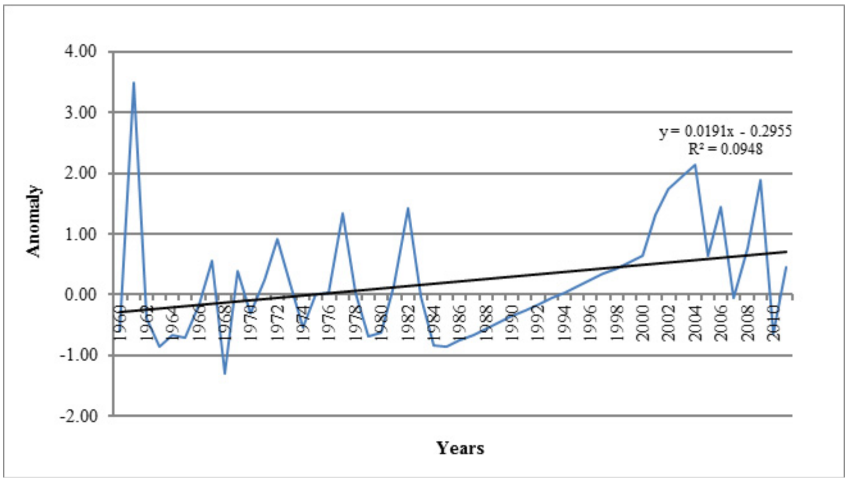

Figure 1. Kotido seasonal rainfall trend (1960-2011)

Kotido variations in precipitation are due to low rainfall amounts received and high seasonal variations. In the period 1987-1990, rainfall decreased by 222.9 mm (30%); the years 1994-1998 saw a drop by 186.2 mm as 16.8% decline; in 2000-2003 precipitation decreased by 34.6 mm (3.9%) and in 2004-2009 rainfall decreased amount fell by 141 mm (9.8%). The trend in Figure 1 appreciates towards the last season of the year which has been found to be critical for agriculture whereby the seasonal trend witnesses slight increase in rainfall but this increase was ($R^2 < 0.5$) found not to be significant. Generally, this unreliable rainfall could hurt agricultural production as less rain days become many with high temperatures and seasons characterized by late onset and early cessation of rainfall with high unreliability impacting negatively on crop production.

Seasonal precipitation trend for Kapchorwa for the past thirty years showed slight increase. For instance 1966-1967 precipitation amounts increased by 74.1 mm (13.4%); 1968-1973 saw increase by 58.6 mm (3.5%). The period 1974-1977 had increase in precipitation by 47.7mm (4.7%). From 1979-1983 rainfall amount received increased by 37.5 mm (4.5%), and in the period 1989-1995, the area experienced increase in rainfall by 67.6 mm (4.8%). Although, the analysis indicates increase, the computed trend for precipitation (R^2=0.0818) was not significant as R^2 value was less than 0.5 (Figure 2). In-spite of this, rainfall amount in Kapchorwa has been increasing though slightly; but still better than for Kotido and could reliably support crop production.

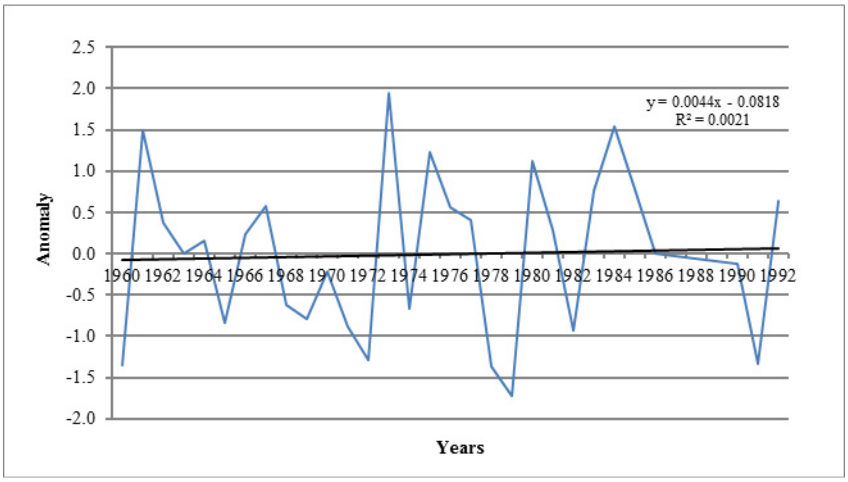

Figure 2. Kapchorwa seasonal rainfall trend 1960-1992

3.3.2 Seasonal Trend for Temperature

Weather behaviour within the seasons in the past 30 years in seasonal changes in temperature indicates considerable changes. Results show (Figure 3) that temperatures in Kotido (Karenga) is increasing at significant rate (y = 0.1716 positive trend; R^2 = 0.7021 high significance) (Figure 3). In other words, the local atmosphere in Kotido is warming up. With low amounts of rainfall, and unpredictable onset and cessation of rainfall, this causes shortage of water and with limited ground water to support irrigation; this could harm crop production significantly

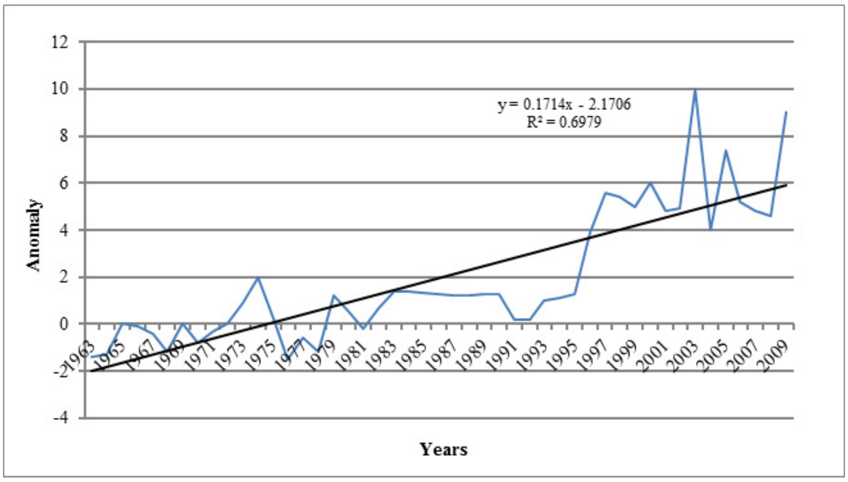

Figure 3. Kotido mean annual maximum temperature (^{o}C) trend

Figure 4 presents the seasonal temperature trend for Kapchorwa and it show that Kapchorwa is also warming up though not at the rate of Kotido (y = 0.0437; R^2 = 0.1629) (Figure 4). This finding conflicts with small-scale farmers' perception and view that temperatures were generally low over the past 10 years. What is clear though is that, being a highland agroecological area, altitude influences temperatures and amounts of precipitation modifying weather and eventually the overall climate, an advantage Kotido (Karenga) misses.

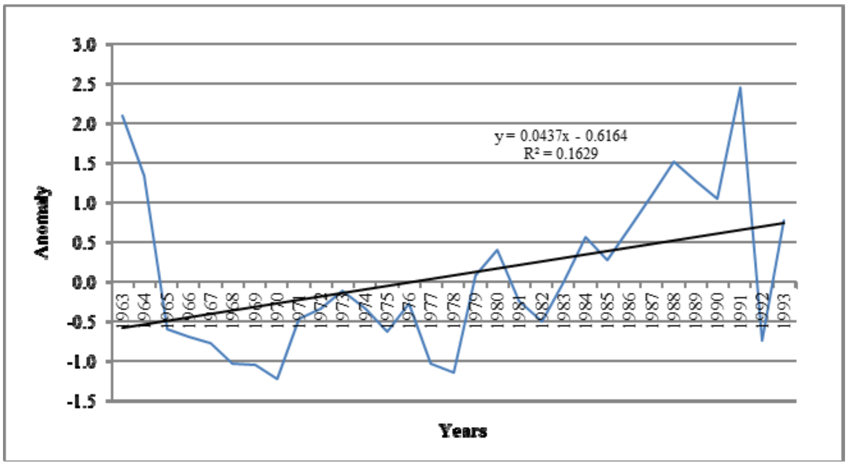

Figure 4. Kapchorwa mean annual maximum temperature (°C) trend

3.4 Effects of Climate Change and Variability on Agricultural Production

3.4.1 Effects of Climate Change on Agricultural Production

Results indicate that climate change and variability impact on small-scale farmers agricultural production is greatly felt already with 61.4% stated had bad effects; 19.1% very bad; 18.9% were slightly affected and only 0.5% not affected (Table 5). Those not affected took up broad off-farm adaptation strategies such as income generating enterprises, adoption of adaptation technologies such as water and soil conservation strategies necessary to cushion adverse climate change impacts.

Table 5. Rainfall variability effects on agricultural production

Variable		**Frequency**	**Percentage**
Rating of rainfall variability and climate change impact on agricultural production in households	Very bad	116	19.1%
	Bad	373	61.4%
	Slightly affected	115	18.9%
	Not affected	3	.5%
Total		**607**	**100.0%**

By cross tabulation, the results indicate that climate change and rainfall variability affected agricultural production and the effect was felt more in Kapchesombe (highland agroecology) (Figure 5). This could be attributed to the sensitivity of mountain ecosystems which is sensitive to any slight change in climatic variables. It could also be due to the recent drought in (year 2013) and still linked to various environmental and edaphic changes that cause reduction in water availability (Deressa et al., 2010). Challenges such as soil degradation, erosion and human population pressure affect and stress up environmental factors and exacerbate effects of climate change including on agricultural production.

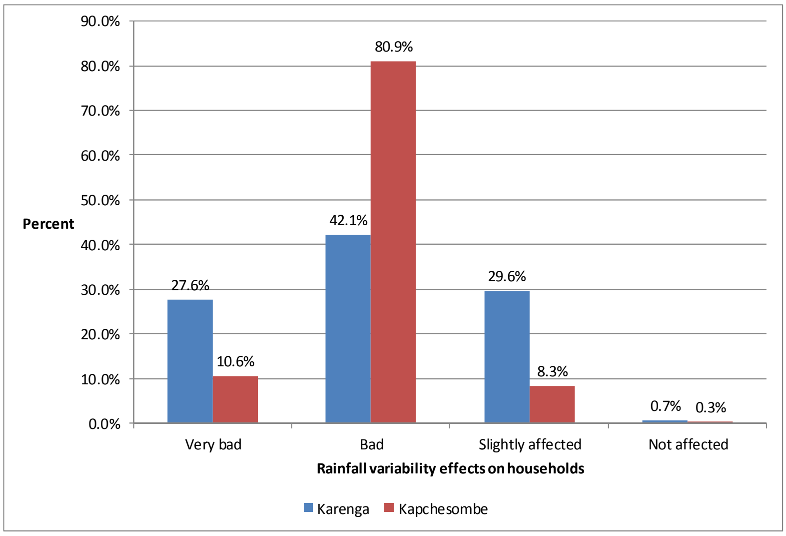

Figure 5. Climate change and rainfall variability effects on agricultural production by agroecology

3.4.2 Effects of Climate Change on Crop Production

Analysis of rainfall and crop production was done to show the relationship between rainfall influence on agricultural production in Kotido (Karenga) and Kapchorwa (Kapchesombe) (Figure 6). The results show crop production trends for Kotido and Kapchorwa from 1981 to 1995 and crops under consideration were cereals (maize) and legumes (beans). Trend for crop production for Kapchorwa appreciated higher than for Kotido (Figure 6).

On average, Kotido recorded the highest precipitation than Kapchorwa with 222.86 and 207.95 mm respectively but these differences were not statistically significant as shown by the p-value of the t-test equal to 0.609 (Table 6). For crop production however, Kapchorwa had an average of 28,111.47 metric tonnes while the average for Kotido was 6,981 and the observed differences in the two means were statistically significant ($p < .01$).

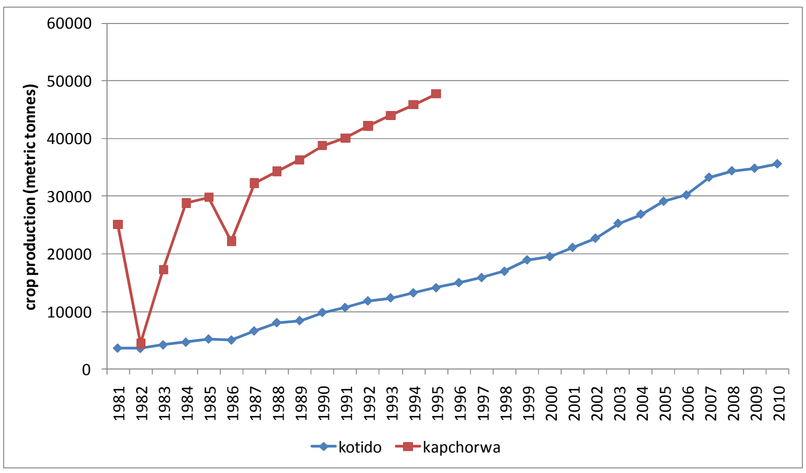

Figure 6. Crop production trend for Kotido and Kapchorwa

Table 6. Results of the t-test on the average precipitation and crop production in the two districts

Variable	District	Obs	Mean	Std. Dev.	t	p
Precipitation	Kotido	27	222.8593	84.50314	0.5156	0.609
	Kapchorwa	15	207.9533	98.81145		
Crop production (tons)	Kotido	30	6981	4355.262	103505	0.000
	Kapchorwa	15	28111.47	9551.284		

Effects of rainfall changes and variability on agricultural production result of the regression analysis (Table 7), the coefficient for precipitation is negative which suggests that an increase in the rainfall by one mm is associated with a reduction in crop production by 8.93 metric tonnes. Nevertheless, it appears that the amount of rainfall received is not a significant factor associated with agricultural production as shown by the p-value of 0.458 > .05. In other words, other factors other than rainfall need to be addressed to improve crop production in the study area. This could include provision of water for agricultural irrigation, undertaking soil and water conservation measures, improving and providing complementary measures such as extension services, awareness and education and demonstrations and agronomic inputs such as access to credit, loans, marketing and production assets and infrastructure required to stimulate agricultural production.

The results however show statistically significant mean differences in crop production in the two districts. Looking at the dummy coefficient for the period 1981-1995, Kapchorwa was able to produce 20,826 more metric tonnes of agricultural output than Kotido and this difference was statistically significant (p = .000) (Tables 7 and 8).

Table 7. Effect of rainfall changes and variability on agricultural production-Kapchorwa

Bean_maize	Coef.	Std. Err.	T	P > t
Mm	-8.93	11.93202	-0.75	0.458
Kapchorwa	20826.06	2188.845	9.51	0.000
_cons	9143.43	2961.575	3.09	0.004
Prob > F	0.0000			
R-squared	0.7042			

Table 8. Effect of rainfall changes and variability on agricultural production in the two study sites (by district)

Bean_maize	Kotido				Kapchorwa			
	Coef.	Std. Err.	t	P > t	Coef.	Std. Err.	t	P > t
Mm	6.747279	10.68563	0.63	0.533	-30.235	25.464	-1.19	0.256
_cons	5648.529	2540.902	2.22	0.035	34398.910	5826.585	5.9	.000
F	0.40					1.41		
Prob > F	0.5335					0.2563		
R-squared	0.0157					0.0978		

3.4.3 How Changes in Climatic Variables and Extreme Weather Events Affected Crop Production

Extreme weather events are already impacting on the small-scale farmers' agricultural production, and 95.1% reported being affected and only 4.9% were not affected. By cross tabulation, 81.3% and 93.6% for Karenga and Kapchesombe reported experience of excessive and stormy rainfall respectively. Impact of such hazards were more on Karenga for instance, crop diseases 94.8%; pests 83.0%; drought 67.0%; floods 63.2% and soil erosion 55.6%. Except for incidences of excessive rainfall, small-scale farmers in Karenga take the brunt of the extreme weather events than their counterparts in Kapchesombe (Table 9).

Table 9. Natural hazards experienced by small-scale farmers

Hazards experienced	**Agroecologies**			
	Karenga (lowland)		Kapchesombe (highland)	
	Frequency	Percentage	Frequency	Percentage
Flood	182	63.2%	22	7.8%
Storm/wind/excessive rainfall	234	81.3%	263	93.6%
Drought	193	67.0%	65	23.1%
Landslide	25	8.7%	24	8.5%
Soil erosion	160	55.6%	104	37.0%
Diseases	273	94.8%	70	24.9%
Mudflow	67	23.3%	90	32.0%
Lightening	80	27.8%	24	8.5%
Pests	239	83.0%	83	29.5%
Earthquake	107	37.2%	3	1.1%

Climate change already is impacting negatively on the small-scale farmers and excessive rainfall was reportedly the highest. Excessive and stormy rainfall caused shredding of crop leaves, broke shoots and flowers; reduced leaf quality, soil erosion, cut off roads, caused root and stem tubers to rot thus causing food insecurity. Reportedly, there is high increase in fungal diseases, soil erosion and hence reduction in the crop yields, ultimately affecting income and livelihoods and quality of life. Affected crops were cassava, potato, tomato, and coffee. In some instances, it has caused premature harvests thus compromising the crop quality. Excessive rainfall caused floods, soil erosion thus leading to reduction of farmlands and declining yields.

3.5 Coping Strategies Undertaken to Adapt to the Effects of Climatic Change and Variability

The small-scale farmers were asked to mention adaptation strategies and necessary changes they made to nutrilise the adverse effects of climatic change and variability in the past ten years and more. The study revealed that coping changes were made in crop agronomy, water and soil conservation. For instance, 84.1% households planted different crops, 71.3% used different planting dates, 64.3% planted different crop varieties, 61.5% made changes in soil and water conservation, 52.1% diversified crops and 45.4% used crops with shortened growing period (Table 10). The changes made were climate-smart strategies adopted to off-set adverse effects of climate change and variability.

Table 10. Adaptation strategies used by farmers (n = 607)

Variable	*Codes*	Frequency	Percentage
Plant different crops	A	508	84.1%
Use different planting dates	B	428	71.3%
Plant different crop varieties	C	387	64.3%
Soil conservation	D	369	61.5%
Crop diversification	E	310	52.1%
Shorten growing period	F	272	45.4%
Change use of fertilizers	G	233	39.0%
Better crop husbandry	H	202	33.7%
Move to different site	I	161	26.9%
Change landsite	J	155	25.8%
Irrigate the farms	K	83	13.8%
Improve storage & post-harvest storage/security	L	64	10.8%
Do water conservation	M	36	6.0%
Change crops to livestock	N	25	4.2%
Use subsidies	O	12	2.0%
Change from farming to non	P	11	1.8%
Use insurance	Q	7	1.2%

4. Discussion

In this study, the analysis of climatic data on rainfall and temperature revealed changes in precipitation where by very slight increase in precipitation has been noticed in the past ten years confirming that there is climate change. Most of the small-scale farmer admitted having observed seasonal changes and variations in rainfall and temperature. This is consistent with Christensen et al. (2007) and Hepworth et al. (2010) where IPCC also presumed increase in rainfall in the horn of and the eastern Africa. The increasing trend in temperature computed through this study confirms what government of Uganda indicated, that there are country-wide changes in climatic variables (Nsubuga et al., 2011) whereby temperatures are increasing and rainfall being erratic. Changes in temperature cause drought and affect crop physiology leading to poor yields. Drought further affects soil water and moisture, causing crop wilting and failure. The poor crop yields and harvests in Karamoja sub-region is largely related to erratic rainfall, unpredictable on set and cessation of rainfall. Strategies that aim at conservation agriculture should address water and soil conservation matters. Extension services to guide farmers, and provision of agronomic in puts is essential. This should be with dissemination of adaptation information using media outlet with widest possible coverage.

This study found that rain days were few and there was increase in non-rain days. There were more warm days than cool days. This means that rainfall amounts to grow crops is generally lacking, a situation that can be further complicated by unpredictable onset and cessation. With poor ground water quantity and sources that are not favourable for irrigation, the future of agricultural production via irrigation in Karamoja is set to be in jeopardy. Unpredictable and increases in rainfall is said to be responsible for landslides on slopes of Mount Elgon in Bududa that destroyed homesteads, agricultural land and fields of crops and human lives (GOU, 2007). In Karenga, floods have destroyed farms reducing sizes of fields of crops, causing roots and tuber crops to rot hence worsening households' livelihoods and food security. Increased temperatures are responsible for proliferation and extending the geographic range of insect vectors such as mosquitoes to higher fronts in Kapchorwa in Mount Elgon, where they were nonexistent in highland areas of Uganda. This affects the residents through malaria outbreaks once there is an encounter with the anopheles species, which is responsible for malaria parasites carrier (MoFPED, 2009). These findings are consistent with World Bank (2010) and Nhemachena et al. (2008) and Okonya et al. (2013) that stated that generally Africa is getting warmer but eastern Africa climate is changing and this will come along with many associated effects causing agricultural and households' decline and food insecurity.

Weather patterns in the country have been very unpredictable in terms of onset and cessation of seasons rainfall leading to low crop yields and instances of crop failure being high (Hepworth, 2010). Great variations in rainfall seasonality in terms of amount, onset and cessation are consistent with IPCC report of likely increase in climatic variables, especially increase in precipitation in eastern Africa (IPCC, 2014; Christensen et al., 2007). In the absence of irrigation technology, if such variations in climatic attributes persist, this could cause crop failure thus affecting agricultural production and livelihoods. In Karamoja sub-region, persistent drought has caused pests and vectors which caused crop failure and affected yields and household livelihoods, leaving the communities impoverished.

Leading extreme weather events experienced were intensive rainfall, drought and floods affecting agriculture variously causing the rotting of pods, roots and tubers and poor seeds and crop decline presumably affecting yields and income as well as food security. On positive note, however, more rainfall enabled farmers to produce more crops with longer seasons' rainfall to enhance household livelihoods especially in Kapchesombe. However, this study revealed that increase in rainfall caused drop in crop yield meaning that rainfall was not the only significant factor in agricultural production but others too; such as other production assets (agronomic input, information, demonstrations, and extension services) required should be provided so as to promote agricultural production and minimize vulnerability. In other words, small-scale farmers' adaptive capacity needs to be enhanced to tackle adverse effects of climate change. The role of central government with development partners is central in this noble responsibility.

Positive attributes and factors that promote agriculture need to be gender balanced, and deliberate effort need to be done to emancipate women with full empowerment for them to have full realisation of their potential. Given that they are basic producers, with knowledge and understanding of natural and environmental resources as they live closer to them, their role in climate change adaptation therefore would be positive once empowered with resources.

5. Conclusions, Recommendations and Policy Implications

The small-scale farmers in Karenga and Kapchesombe are vulnerable communities to changes in changes in climatic variables and the high frequency of extreme weather events (drought, floods and destructive winds) coupled with stressors factors such as diseases, pests, floods and bushfires have resulted into the loss of gardens and low yields. Vulnerability has undermined small-scale farmers' adaptive capacity and is almost in no position to acquire essential adaptation technology due to high household poverty levels because their agriculture is dependent on natural rainfall that is unpredictable. This has translated into poor income and livelihoods, food insecurity and hence low adaptive capacity.

Government need a multi-approach to address the challenge of adverse climate change impacts that involves improvement of agricultural production assets, such as development of human and social capital through farmers capacity development to adopt climate-smart agricultural techniques to address climate changes through the acquisition of knowledge, agronomic inputs such as agrochemicals, fertilizers, tools and use of improved crop varieties that can cope up with high erratic seasonal changes. Agricultural modernization needs a holistic thinking and planning and working closely with small-scale farmers with climate change at the centre of agricultural modernization planning and implementation.

The small-scale farmers in Karenga and Kapchesombe have limited capacity, resources, funds, extension service support and the essential adaptive technology to effectively respond to adverse effects of climatic variability and change. The government should expand farm-to-farm extension service to the farmers, who must be explained and should recognize the role of extension services and be able to access deployed resources and information at their disposal to tackle adverse effects of climatic variability and change. Accordingly, through extension services, farmers could then be provided to receive climate–smart agricultural skills and knowledge for crop production to engage in better profitable agriculture. Government should train and provide refresher training to extension workers in delivery of extension services that should be holistic including techniques of transferable skills in crop agronomy, resources delivery and use for effectiveness and designing demonstrational learning programmes to improve adaptive skills in climate-smart agricultural production and improved household livelihoods including off-farm adaptation enterprises establishments.

The role of extension staff should be mainstreamed into the centre of development planning both at central and lower local government in the districts. Government needs to develop districts capacity to handle climate change effectively at lower grass-root levels by equipping production officers with knowledge and skills in explaining the roles of extension officers to small-scale farmers in Kaabong and Kapchorwa districts which must include use and adoption of appropriate adaptation technology, use of site-relevant adaptive technologies and crop husbandry. Delivery of information through demonstration plots, organized study tours and through media have great potential in inculcating and improving small-scale farmers adaptation capacities to climate change. Effort towards addressing cultural rigidity to adaptation can not be over-emphasised and deliberate awareness to address it be emphasized.

The central government early warning systems and impending eco-disasters based on climatic forecasts should be relayed to the farmers through appropriate media channels with widest coverage at grass roots, including the local frequency Modulation (FM) radio stations and also print media. Disaster preparedness in prevention and saving of lives be improved. Farmers in Mount Elgon need to be given techniques in landslides prevention as well as shown areas prone to landslides be zoned and made known to the people.

Lastly, climate change is there and to effectively adapt, farmers need to use available adaptation information proposed through this study. With reformed extension services, well packaged information and farmers demonstrations, tours, public talks and lectures, learnt techniques in agronomy integrated with indigenous coping strategies can help small-scale farmers to go a long way in adaptation to adverse climate change effects.

Given that this is happening on the door steps of Uganda Wildlife Authority (UWA) estates of protected areas, UWA need to be involved and develop comprehensive and broad programmes for indoors and communities' climate change adaptation with programmes that will involve stakeholders' to address household livelihoods, embrace conservation and tackle climate change challenges. In all this, central and lower local government relevant departments and NGOs and development partners need to cooperate and work together.

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