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Small-scale Farmers Adaptation to climate Change in North-Eastern and Eastern Uganda: Evidence for Policy

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Abstract
Climatic models for Uganda indicate that its climate is highly variable with frequent occurrence of extreme weather events such as flood, drought and intense rainfall, which will affect agricultural production and small-scale farmers' livelihoods and adaptive capacity. Adaptation to climate change is panacea to address the adverse effects of climate change and varies from one area to another and farm to farm. Given the level of adverse effects and high amount of vulnerability of the small-scale farmers to climate change, adaptation is imperative to secure livelihoods and adoption of coping strategies to nutrilise the adverse effects of climate change. Different coping strategies can be designed to address effects of climate change which small-scale farmers already are doing. However, looking into the impact of climate change, in the past and the expected change in the future, it is imperative to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Planning adaptation and adapting to climate change requires an understanding of the current situation, adaptive capacities, of small-scale farmers directly affected by climate change. The objective here was identify adaptation strategies at farm level and factors influencing adaptation choices. This study was comparative and set in Karenga (lowland) and Kapchesombe (highland) agro-ecological zones in the North-eastern and Eastern Uganda respectively and the location next to national parks makes the study important in that climate change effects on neighbouring communities could have livelihood and conservation implications. It investigated the determinants influencing the adoption of different coping strategies by the small-scale farmers in the study areas adjacent to the major national parks. A sampled data of 607 households heads and the study employed multistaged and systematically randomly sampled the small-scale farmers. The study used Multinomial logistic regression model to determine the likelihood of choice of adoption of coping strategies in relation to factors (determinants) affecting the choice of adoption of adaptation strategies to tackle adverse effects of climatic change and variability and found that small-scale farmers were already aware of changes in climatic variables over the past twenty years; and small-scale farmers employed water and soil conservation measures such as planted different crops, used different planting dates, planted different crop varieties, under took soil conservation, implemented crop diversification and shortened growing period. The results revealed that factors that were significantly associated positively in determining the likelihood of adoption of coping strategies included agro-ecological location, gender of the household head, knowledge of climate change policy, desire for natural resources from the national park due to the effects of climate change, main sources of income, and the frequency of radio listenership on climate change. At bivariate level, the revelations of socio-economic characteristics significantly associated with adaptation were education, period of stay in community and income sources. The results revealed that the small-scale farmers were vulnerable to the effects of climatic changes and variability on agricultural production that is rainfed. Interventions need to be broad to address climate change challenges such as lack of awareness, inadequate and non-productive extension service and the in adequate access to relevant adaptive technology. In other words, it should encompass integrated and holistic programmes that address livelihoods, food security, climate-smart agricultural production and sustainable natural and environmental resources conservation that are gender sensitive fronting women empowerment in climate change adaptation decision-making with full agronomic support.
Keywords: climate change, variability, adaptation options, determinants and policy.-

1. Introduction

Climate change is reality and with us, no doubt and is very important issue in mass media, sector-wide planning and national strategic policy process (Maponya and Mpandeli, 2013). According to IPCC (2014), the human interface with climate systems is occurring and climate change poses risk for human and natural systems and the IPCC Fifth Assessment Report presents how patterns of risks and potential benefits are shifting due to climate change. The Fourth Assessment Report of the Intergovernmental Pannel on Climate Change (IPCC) presents summary of the expected adverse impacts of climate change with the main projected future climate change being variations in the climate variables (temperature, precipitation and humidity); very likely greater than what was observed in the twentieth century. The report underscores likely increase in incidences of heat waves, and intense rainfalls with extreme weather events such as floods and drought and in non-linear unpredictable scope (IPCC, 2007). In particular, key attributes pointed in the IPCC Fourth Assessment for Africa was that warming is very likely to be larger than the global annual mean warming throughout the African continent, however, there is likely to be an increase in annual mean rainfall in east Africa, Uganda inclusive. The sub Saharan Africa is affected by climate change and is one of the leading environmental challenges (Nhemachena, 2008) and there is already increasing concern globally regarding changes in climatic variables (temperature, precipitation and humidity) that are threatening to the transformation of livelihoods of the resource-constrained rural communities in eastern Africa (Tafesse *et al*, 2013; Watson, 2010; Smit *et al*, 2000).

Adaptation is a process by which individual communities and countries seek to cope with the consequences of climate change and the process of adaptation is not new; the idea of incorporating future climate risk into policy-making is (Lim *et al*, 2004). Climate change affects agriculture. Higher temperatures for instance are said to be responsible for the reduced rainfall and increased rainfall variability, causing reduction in crop yields, thus threatening to undermine foods security in the agro-based economies in the sub-Saharan Africa (Tafesse *et al* , 2013; Deressa *et al*, 2010; Yirga and Demeke, 1996). According to Tafesse (2013), the agricultural sector is constrained by factors such as soil degradation due to overgrazing, deforestation, poor complementary services such as extension, credit, marketing, infrastructure and extreme weather events such as floods and drought and effort to off-set them is inadequate due to limited resources allocated to address them. Deressa *et al* (2010) also stated that most of the above factors identified as affecting agricultural production are related to the development of institutions and infrastructure which are often in poor state.

Uganda has continued to experience adverse effects of climatic changes and variability sector-wide and is of great concern as the agricultural production underpins the country's economic dependency (NCCP, 2012; Rwakakamba, 2011; NDP, 2010). IPCC (1996) stated that there will be increase in annual mean rainfall in east Africa and intimated further that climatic changes effects will not be uniform. Studies (Okonya *et al*, 2013; Rwakakamba, 2011; NDP, 2010; DFID, 2005) have shown that climate change has affected agricultural production in Uganda because it remains the main source of income and livelihoods for most of the rural communities in a country that has a highly variable climatic variables that imperatively deems that the small-scale farmers adopt adapt strategies to cope with the adverse effects. Additionally, various studies (Rwakakamba, 2011; Hepworth, 2010; Hepworth and Goulden, 2008; and Orindi and Eriksen, 2005) intimated Uganda's climate being naturally variable and susceptible to extreme weather events such as floods and drought and intense rainfall, erosion and outbreak of pests and diseases which have negative socio-economic impacts in the recent past. However, the majority of these studies are content reviews of documents and reports and short of critical analysis of small-scale farmers' perception and factors that determine the adoption of coping strategies; an area that is still grey, the focuss of this study.

A variety of studies have demonstrated that the rural small-scale farmers in Africa have perceived and responded differently to the challenge of adverse effects of climatic changes and variability (Gukurume, 2013; Salau, 2012; shewmake, 2008; Maponya and Mpandeli, 2012), however, none of the studies is in Uganda. Equally, no studies has been done on climate change determinants in areas bordering protected areas (national parks) and possible policy implications this has in the country.

Studies by Nhemachena (2008) investigated adaptation of African farmers to climate change at continental scale. Though informative, it was at continental level and yet climate change impacts vary significantly even at local level and adaptation therefore should be site-specific and sometimes garden-specific to address the environmental and as well physical adaptation challenges.

Gbetibuo G.A. (2009) assessed the understanding farmers' precipitation and adaptation to climate change and variability in Limpopo Provence of South Africa. Though informative, it did not bring out determinants of adoption of coping strategies the farmers use. Besides, this study was in South Africa, among 'furnished' and 'supported' farmers that enjoy government support. This case scenario is not congruent to Karenga and Kapchesombe situation in Uganda.

Kurukulasuriya, P. and Mendelsohn, R. (2006) analysed, using a Richardian approach, the impact of climate change on African cropland. This was informative, but treated economic impacts without regard to factors influencing choice of adaptation strategies to address adverse effects of climatic changes and rainfall variability.

Study by Okonya *et al* (2013) investigated farmers' perception of and coping strategies to climate change in Uganda. Though informative, the study was restricted to potato growing farmers distributed in six agro-ecological zones in the country. Given this restriction and the sample size, and the regional and the national nature of the sampled area, the study mainly quantified perception and adjustment of the farming practices; and short of presenting investigated factors that influenced choice of adaptation strategies. The concept of adaptation is not new as throughout human history societies have adapted to natural climate variability through socio-economic adjustments (Adger,2003) . Enhancing the abilities of small-scale farmers to cope with adverse effects of climate change is imperative and requires addressing local vulnerabilities and challenges and ensuring that decisions and initiatives taken are compatible with existing decision processes (Brooks *et al*, 2005).

This study concurs with Fussel (2007) assertion that emphasis should focuss on adaptation because human activities have already affected climate, climate change continues given past trends, and simply the effect of emission reduction will take several decades before showing results. This study adds that, the emerging countries are not will to stop their development process by cutting emissions and therefore underscoring the great importance of adaptation by all the stakeholders.

Given Uganda's variable climatic resources and dependence on rainfed agriculture, highly vulnerable small-scale farming community, it's just important for the country to prepare sector-wide adaptation strategies and this is based on detailed studies on adaptation strategies and factors that influence such coping strategies. Farm-level and place-based adaptation and factors affecting adaptation for vulnerable small-scale farmers are not documented. The sole objective of this study was to identify widely used coping strategies to climate change adaptation at farm-level and determinants affecting choices of adaptation strategies. We also, documented and quantified perception on climatic variability, adjustments in coping strategies adopted and determinants to adaptation; and done in the context of adapting to climate change in areas bordering protected areas.

2. Materials and methods

2.1 Survey Design and Study Area

This study used both qualitative and quantitative methods of data collection whereby households' survey questionnaires were administered to 607 households and the questionnaires reflected sections on socio-economic and demographic characteristics, perceptions of and adaptation to climatic change impacts. It also portrayed determinants that influenced choice of adaptation strategies.

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.

2.2 The study area

This study was carried out in Northeaster and eastern Uganda in the administrative districts of Kaabong and Kapchorwa. They were selected mainly because they are rich agricultural zones in the country, lying in the cattle corridor, an area with high temperature and rainfall variability and are located on the plains of Karamoja and the Mount Elgon respectively. The two study areas were Karenga and Kapchesombe sub-Counties in Kaabong and Kapchorwa districts, respectively; purposely chosen due to their location in areas within 5 km from the protected areas borders. Karenga is located at 03^0 54'N-33^0 51'E and Kapchesombe at 01^0 09'N-34^0 33'E; both are transboundary and contiguous protected areas and ecosystems across South Sudan border with Uganda in the Northeast and with Kenya border in the east respectively.

According to FAO (2007), the two study areas are characterized by attributes unique to each of the sites. Karenga for instance lies in the critical Kidepo landscape is in Kaabong district within the Karamoja wet zone (agro-ecology) which encompasses northeastern, mostly the border areas with south Sudan; with rainfall of 1100 mm per annum with altitude ranging 970-1420 m a.s.l. the area has moderate good soils.

Kapchesombe sub-County is located in the eastern highland of Kapchorwa district. The area covered by mostly Mount Elgon with rainfall over 1400 mm at an altitude of 1300-3600 m above sea level. The soils are volcanic and rich. The inhabitants are the kalenjing speaking Sabin people who practice mixed crop and livestock keeping agriculture.

2.3 Sampling technique

In this study, multi-stage 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 selected using systematic random sampling.

2.4 Analytical methods

Previous studies reveal that approaches commonly used in an adoption decision involving multiple choices are the multinomial logit (MNL) (Kurukulasuriya and Mendelsohn , 2006; Nhemachena, 2008 and Tafesse *et al*., 2013). MNL has lent its self as important statistical tool for multiple decisions analysis because such decisions are jointly made and the MNL has been found appropriate in evaluation of alternative combinations of coping strategies (Hauseman and Wise, 1978 and Wu *et al*., 1998).

In a similar vein, the MNL was applied to analyse crop choice selection (Kurukulasuriya *et al*., 2006 and Temesgen *et al*., 2010) and livestock choices (Seo and Mendelsohn, 2008) and as a model in analysing the decision to adapt to adverse impacts of climate change and variability (Nhemachena, 2008). The merit of the MNL model is that it permits the analysis of decisions across more than two categories allowing the determination of choice probabilities for different categories (Wooldridge, 2002; Panneerselvam, 2012). Additionally, the appropriateness and ease in estimating interpretation is widely recognized (Green, 2012;).

Let Yi be a random variable representing the adaptation measure chosen by any farm household. We assume that each small-scale farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climatic attributes, socioeconomic and demographic characteristics of the small-scale farmers and other factors X. the MNL model for adaptation choice specifies the following relationship between the probability of choosing option Yi and the set of explanatory variables X (Green, 2012).

$$\Pr(yi=j)= e^{\beta_i x_i} / \sum^{j}_{k=0} e^{\beta i x i} = 0, 1\ldots\ldots\ldots j \quad (1)$$

Where β_j is a vector of coefficients on each of the independent variables X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that β_0= 0, 1 and the probabilities can be estimated as:

$$\Pr(Yi=j/xi) = e^{\beta j x i}/1+\sum^{j}_{K=1} e^{\beta' k x i,} \quad j= 0,1, 2\ldots\ldots\ldots J, \ \beta_0 = 0 \quad (2)$$

Estimating equation (2) yields the J log-odds ratios

$$\text{In } (P_{ij}/P_{ik}) = X'_I (\beta_j - \beta_k) = X'_i \beta_{j,\ if} \ K = 0$$

The MNL coefficients are difficult to interpret, and associating the β_j with the *jth* outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived (Green, 2012).

$$\partial P_j / \partial X_i = P_j \, [\beta_j - \sum^{j}_{K=0} \overline{P_k} \beta_k] = P_j \, (\beta_j - \beta) \quad (3)$$

Where P is the probability, X is socioeconomic characteristics and other factors and β is a vector of coefficients. The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Tafesse, 2013; Long, 1997; and Green, 2012). The signs of marginal effects and respective coefficients may be different, as the former depends on the sign and magnitude of all other coefficients.

Finally, the model was run and tested for the validity of the independence of the irrelevant alternatives (HA) assumptions by using the Hausman test for IIA and the seemingly unrelated post estimation preside (SUEST).

2.5 Empirical model

Previous studies (Tafesse *et al*., 2013; Green, 2012; and Nhemachena, 2008) found that perception and adaptation strategies to climatic changes are influenced by the socioeconomic, demographic and environmental factors. In this study we hypothesised factors that affected perception and adoption of adaptation strategies to include: agroecological zone, gender of the household head, support obtained, interaction with extension staff, working fulltime on the farm, access to natural resources, income to address climate change challenges, knowledge of the climate change policy, experienced natural hazard, desire for resources from the national park, sources of income and frequency of listenership on climate change issues. Other attributes looked at were education, period of stay in the community, age, family size and household assets.

2.6 Dependent and independent variables

In this study, the dependent variable was the choice of an adaptation option from the set of adaptation measures listed in table 10. The responses of these strategies were summed up to create and generate an index for the overall measure of adaptation which ranged 0-17 with high scores signifying the adoption of several strategies and vice-versa. Independent variables are factors that influence perception and adaptation enumerated in Table 9. Small-scale farmers were then categorized as falling into three categories: a) none- implying that no adoption of any coping strategy and was the base category; b) adopting 1-4 strategies; and c) five and above (5≥) strategies adopted. This categorization enabled the researcher to determine the factors that influenced adoption of adaptation strategies.

3. Results

3.1 descriptive results, perception of small-scale farmers to climate change in the past 20 years

3.1.1 Changes in precipitation

This section presents descriptive results on the perception of the small-scale farmers on changes observed in the climatic variables such as rainfall, temperature, extreme weather events like floods, drought, pests and diseases and the environmental impacts of climate change in the study area.

Small-scale farmers' perception on precipitation changes over the past 20 years was assessed and the results show that more than fifty percent of the respondents 50.2% (n=305) indicated increase in rainfall; 29.0% (n=176) revealed decrease in rainfall; and 17.8% (n=108) claimed that rainfall altered while .5% (n=3) stated no change and 2.5% (n=15) did not know anything. From this result, it is shown that slightly more than half of the respondents 50.2% (n=305) observed an increase in rainfall (figure 1). This means that according to the respondents there was more precipitation and this has got implications in agricultural production. If the rainfall is well distributed it would boost production.

3.1.2 Changes in temperature

Respondents' perception on temperature changes over the past 20 years was assessed. The results show that respondents' perception in temperature variations indicate that the majority 44.0% (n=267) believed that temperatures decreased, while 31.0% (n=188) indicated that temperature increased. Those who saw no change were 5 respondents (.8%); while 2.5% (n=15) did not know as shown in figure 5.2. This result shows that community were able to detect change in temperature in terms of decrease and/or increase in insolation and temperatures given that they also saw more precipitation in the same period of time. It may mean that variability was not much in temperature, but could have been in terms of precipitation. This is in line with the weather models for Uganda, (UNCCP, 2012; NDP, 2010; IPCC, 1996).

3.1.3 Climate change effects on environment

Small-scale farmers were asked on the effects of climate change on the environment. It was found out that climate change affected environment with wide and varied impacts. For instance, 18.6% stated that it caused land conflicts; 89.4% reported reduction in agricultural output; 44.0% stated that it caused fall in household income; 64.9% reported outbreak of diseases arising from climatic variability; 20.6% claimed that climate change led to water contamination; and 2.7% indicated soil erosion. The study areas revealed that generally Karenga suffered more impacts than Kapchesombe for instance, water contamination (20.6%) in Karenga than in Kapchesombe (0.4%). This arise due Karenga being lowland agroecology where all the waters of Napore Nyangia Mountain ranges flow to the lowland causing floods, sedimentation and siltation of the waterholes, rivers and reduce sizes of agricultural fields in Table 2.

3.1.4 Rainfall variability as major factor affecting household livelihoods

Climate change has been reported to negatively impact on vulnerable rural communities in Africa (FAO, 2008; Okonya *et al.*, 2013; Nhemachena *et al.*, 2008) and one of the research questions in this study was whether climate change and rainfall variability was a major factor affecting small-scale farmers' household livelihoods in the study area? The majority of the small-scale farmers attested to it as true that their livelihoods have been affected by rainfall variability (84.7%). However, when cross-tabulated by the sub counties (agroecologies), the results indicate that the strongest effect was reported in Karenga sub-county (lowland agroecology) (57.1%) than in Kapchesombe (highland agroecology) (42.9%). This fact may be attributed to the fact that the small-scale farmers in Kapchesombe have off-farm income and other adaptation options such as mixed crop and livestock keeping thereby with sustainable strategy to counter climatic shocks than their counterparts in Karenga where such strategies are lacking (Table 2). Clearly, the also have in place undertaken changes with respect to crop varieties and in the management of crops, soil and water.

3.2 Climate change effects on agricultural production

3.2.1 Changes in climate effect crop production

Analysis of perceived effects of climate change on crop production revealed that already climatic changes are happening with significant effects, impacting crop production. Small-scale farmers (19.2%) noticed having experienced floods that ha-s become more frequent in the last ten to twenty years affecting crop production negatively with effect being soil erosion, reduction of farmland areas, rotting of tubers and roots, outbreaks of diseases, ground water logging, and crop failure in the last twenty years.

Up to 35% of the sampled households perceived drought and prolonged dry-spell as increasing. Heat causes crop wilting and drying up. This is often associated with termite and insect pest attacks. These effects cause crop failure; a phenomenon most prevalent in Karenga. This could be associated with rainfall pattern, characterized by unpredictable onset, cessation and uneven distribution, an edge Mount Elgon (Kapchesombe) has over Karenga.

Small-scale farmers (16.9%) sampled noticed that over the past twenty years rainfall onset and cessation has changed with more uncertainty and predictions. Early warning and meteorological information differs with precipitation and weather patterns thus affecting farmers' crop calendar and increasing vulnerability. This needs to change and improve.

The same proportion (16.9%) perceived that rainfall intensity has increased with higher frequencies of extreme weather events with similar effects on crop production like floods. this was most felt in Karenga (lowland).

Climate change variability manifested (15.8%) in form of hailstorm and extreme rainfall, gales resulting in a variety of effects on crops: shredded leaves, broken flowers and stalk and poor leaf quality thus affecting crop phenology and yield. Poor yields affect income and food security and increase vulnerability.

On a positive note though, 04% of the respondents observed longer and more rainfall which was beneficial by providing longer growing season and time and increased yields. With this come bumper harvests, food and income as small-scale farmers are able to meet their needs and access adaptation technology. This was expressed in both agro-ecologies under study (Table 3).

3.2.2 Climate change and variability effects on household economy

The small-scale farmers were asked about climate change and variability effects on the household economy in the two agroecologies. Results reveal that in Karenga and Kapchesombe, climate change and variability affected their household economy by 63.8% and 93.1% respectively. Only 5.6% respondents (small-scale farmers) for Kapchesombe indicated that rainfall variability affected their household economy as compared to 49.2% for Karenga. Both areas reported small number of respondents whose households were not affected by climate change and variability at all as shown in table 4.

The level at which the household economy is affected by climate change and variability was found to be significant (p=.000) related with the agro ecological location where the percentage show that respondents in Kapchesombe (93.1%) perceived this variability higher than that of Karenga (63.8%) (Table 4). This result indicate that climate change and rainfall variability affects household economy but households of Kapchesombe experienced the effect more because mountain ecosystems are more sensitive to slightest change in weather events than the savanna agro-ecology such as Karenga.

3.2.3 Climate change effects on food security

Climate change and weather effects on food security was analysed, nearly all respondents 96.7% (n=587) indicated that climate variability affect their food security in different ways: those that indicated decline in crop production were 97.4% (n=533); 37% (n=205) indicated decrease in pasturelands. However, 56.1% (n=307) indicated fodder production increase due to climate change and 45.2% (n=247) indicated more water for livestock as shown in Table 7. Disaggregated by agroecologies, both Karenga and Kapchesombe reported decline in crop production by 96.0% and 98.9% respectively in Figure 4.

Conversely, climate change and weather variability was reported to have contributed to increase in fodder production at 52.7% and 59.6% for Karenga and Kapchesombe respectively. The rate of decrease for pastureland was higher for Karenga 59.9% than for Kapchesombe 14.4% meaning that Kapchesombe practices zero grazing unlike the free ranging option of grazing in Karenga. This simply confirms that Kapchesombe respondents practiced livestock and crop farming as adaptation strategy compared to their counterparts in Karenga. The findings reveal that there was decrease in pastureland in Karenga as indicated by the 59.9% of the respondents (Figure 4). This could be attributed due to the fact that more land was being opened up for crop farming given that the respondents stated increase rainfall which is ideal condition for crop cultivation. However, the implication of climate change effects on food security were noticed more negatively in crop production and results indicate both Karenga and Kapchesombe are being food insecure with Karenga most affected.

3.3 Adaptation strategies and changes made in management of crops, soils and water conservation

The small-scale farmers were quizzed in the interview of the changes they saw necessary and made to counter climate change effects in the over the past twenty years. The study found out that, small-scale farmers were aware of changes in climatic variables and asked adaptation changes the farmers actually employ as appropriate coping strategies. The survey show that 84.1% planted different crops; 71.3% used different planting dates; 64.3% planted different crop varieties; 61.5% undertook soil conservation; 52.1% diversified crops and 45.4% shortened the growing period. While 39.0% and 33.7% employed change in use of fertilizers and adoption of better crop husbandry respectively (Table 5).

These changes aimed at use of better crop varieties that can not only withstand weather vagaries, but also withstand diseases, meet water shortage challenges and edaphic constraints while yielding in drought and erratic rainfall situations to avoid total crop failure. These measures help small-scale farmers guard against losses emanating out of increasing temperatures, erratic precipitation and frequent occurrence of extreme weather events such as drought and floods. They have coped by planting different crop varieties at different times, and by employing adaptation strategy 'of not putting all eggs in one basket'. These measures also maintain soil texture and quality through nitrogen fixing, manuring, mulching and soil moisture conservation. Tree planting and agroforestry measures undertaken through tree planting provided fruits, timber, poles and charcoal thus meeting non-food needs in the households (Table 5).

3.4 Determinants of adoption of coping strategies: the multinomial choice

3.4.1 Environmental and socio-economic factors

The actual coping strategies by the small-scale farmers are grouped into 17 categories (Table 7). The responses from these strategies were summed to create and generate index for the overall measure of the adaptation which ranged from 0-17 with high scores signifying the adoption of several strategies and vice-versa. After computing the score (0-17) small-scale farmers were then categorized as falling into three categories: a) none-implying no adaptation; b) 1-4 strategies adopted; c) more than 5 strategies adopted. The justification enabled the small-scale farmers to determine the factors that influenced adoption of coping strategies.

Results indicate 3.3% did not adapt any strategy at all, 34.9% adopted 1-4 adaptation strategies, 52.3% adopted 5-8 strategies and 9.5% adopted more than 8 coping strategies (figure 4). On average farmers in Karenga adopted 4.1 coping strategies and in Kapchesombe 6.6 strategies and the difference was statistically significant (p=.000). In other words, farmers in Kapchesombe adapted to adverse climate change effects more than their counterparts in Karenga because mountain ecosystems are sensitive to any changes in climatic variables and farmers were quick to perceive such effects and accordingly make necessary adaptation changes in crop, soil and water management to counteract climate change effects.

This study presents two models: a) the first model for respondents that adopted 1-4 strategies, and b) the second model for small-scale farmers that adopted more than 4 coping strategies. To determine factors influencing choice of the coping strategies, multinomial logistic regression predicting the number of coping strategies adopted to cope with the adverse effects of climate change and is presented in Table 4. Table 5 presents the MNL regression predicting the likelihood of adoption of adaptation measures.

In this study, the multinomial logit (MNL) model analysed coping strategies adoption decisions involving multiple choices; and the dependent variables was the empirical estimation from the set of adaptation measures in table 7. The exploratory variables (independent variables) in this study were chosen based on climate change adaptation literature reviewed and available data generated from the field. The variables include the socioeconomic and demographic characteristics of the small-scale farmers, knowledge of climate change policy, gender of the respondent, support received to address adverse impacts of climate change, the agroecological location, interaction with extension staff, working on farm on full-time basis, access to natural resources, farmer's knowledge of the Uganda climate change policy, if affected by natural disaster, income enabled farmer to address climate change challenges, desire for resources from the national park, sources of income and listenership to radio on climate change programmes. The definitions of the variables used in the empirical analysis are presented in table 6.

Probability of adoption of particular adaptation strategy computed based on explanatory variables was wide and varied. For instance, influence of agroecological zone appeared to be significant (p=.000) factor in predicting the likelihood of adopting strategies to tackle adverse impacts of climate change. The study established that small-scale farmers in Kapchesombe (highland) were more likely to adopt 1-4 strategies to adapt to climatic changes and variability than their farmers in reference category (Karenga, lowland). This was given by the positive dummy coefficient (t=23.05). In other words, individuals from Karenga were more likely not to adopt any strategy as opposed to Kapchesombe. These results are in agreement with the t-test where on average, farmers in Kapchesombe had an average of 6.6 coping strategies as opposed to those in Karenga whose average was 4.1 coping strategies. This difference was statistically significant at 99% confidence interval. The probable reason for this high level of adaptation could be due to the sensitivity of mountain ecosystem to any slight change in climatic and weather variable. The farmers therefore took preventive and anticipatory coping strategies.

Gender analysis revealed that male farmers were more likely to adopt 1-4 or above coping strategies as opposed to female counterparts. This is not consistent with Maponya and Mpandeli (2012) who found that female were more likely to adopt more adaptation strategies than their male counterparts because of being the main food producers and feeding the family and are always interacting with environment and natural resources and are aware of climate change impacts. However, in the study areas, the communities are male dominated society and are favoured in accessing land, agricultural input, access to loan, insurance, agrochemicals and have final say over natural resources and yet absent in production circle hence undermining adaptation efforts. Despite these revelations, the finding did not reach statistical significance (p>0.05). In other words, the number of strategies adopted was not significantly dependent on the gender of the small-scale farmer.

Obtaining support to address the adverse effects of climate change was found to be insignificant factor in explaining the likelihood of adopting 1-4 or more coping strategies, thus creating a big surprise. Also, small-scale farmers' interaction with the extension farmers was insignificant factor in explaining the likelihood of choice of adaptation strategies to nutrilise adverse effects of climate change. This result shows that although the farmers who interacted with the extension staff were likely to adopt one or more strategies, compared to those in the base category (who did not obtain support). The results however, show that the interaction was not statistically significant. This revelation is disturbing and not consistent with Nhemachena (2008) and Maponya and Mpandeli (2013) who found out that agricultural extension services role is educational, in provision and dissemination information to farmers and provide support needed and to guide the farmers in adaptation to climate change decision making. This may be explained in terms of low capacity in extension services and climate change adaptation strategies.

Fulltime employment on the farm was a factor inversely (negatively) related with the choice of adopting 1-4 coping strategies and above. This implies that small-scale farmers working fulltime on their farms were more likely not to adopt adaptation strategies than the partially employed. This finding was significant in the case of employing 1-4 strategies (p=.016). This finding is not in tandem with Nhemachena (2008) established that fulltime farmers will not be affected much by climate change because they are aware more likely to have more information and knowledge on changes in climatic conditions. In this place, most small-scale farmers are migrants from elsewhere and therefore not fulltime. However, maximize output by employing adaptation strategies.

Access to national park extractive resources as factor in predicting probability to influence adoption of 1-4 adaptation strategies revealed that small-scale farmers who accessed resources were less likely to adopt any adaptation strategies as opposed to famers who had no such privilege to national park resources. In spite of this finding, this factor was not a significant determinant in predicting the likelihood of choice of adoption of adaptation strategies. However, dependence on the resources from the national park is likely to impact negatively on the ecosystem health if extractive resources off-take is not well regulated.

Knowledge of the Uganda national climate change policy in the multivariate model was found to be a highly significant (p<.05), with positive relationship was found for the dummy coefficients among small-scale farmers who reported having knowledge of the policy. This means that knowledge and information on the policy was a significant predictor for adoption of 1-4 (p=.024) and 5 strategies and above (p=.047). In other words, having knowledge and information on climate change policy reduces the likelihood of not adopting any strategy. This is not surprising because policies set roadmaps where institutions and nations want to go and the Uganda national climate change adaptation policy has set priority adaptation and mitigation strategies and/or recommendations that every able bodied person is obliged to implement to tackle adverse impacts of climate change. These strategies are agricultural, agroforestry, land management and use, water use and sustainable management and sustainable business. This knowledge on the policy guides in rational decision making and adoption of optimal adaptation strategies to nutrilise adverse climatic change impacts.

Natural hazards effects on livelihoods as a predictor in adoption of adaption measures was found to have negative relationship between respondents who mentioned that natural hazards affected food production. According to the results, the farmers were less likely (p=.216) to adopt to employ 1-4 strategies than their counterparts in the reference category and the effect was however insignificant (p=.175). However, in relation to adoption of 5 strategies and above, this factor was statistically significant (p=.024). This could be attributed to the fact that a combined approach needs to be adopted to address multiple effects of natural hazards. In other words, a combination of adaptation strategies approach is the best approach including adoption of crop varieties agronomy and husbandry, adoption adaptation technology, soil and water conservation measures and off-farm approaches to tackle effects of natural hazards.

Income as factor to predict likelihood in adoption of strategies in this study did not support the assumption that a fall in household income plays a significant role in explaining whether the individual would adopt or not adopt any strategy. In other words, the level of adoption of strategies between those who have been affected and the base category (whose income not affected) is the same. In other words, those whose income has not been affected by climatic change have adapted although not to statistical significance. This finding is disturbing and not consistent with Lapar and Pandley (1999) and Kurukulasuriya and Mendelsohn (2006) who found out that higher income and farm wealth inform of machinery and farm assets significantly and positively increased net farm revenue on African cropland. The above situation could be attributed to the high household poverty levels that cannot afford purchase of adaptation technology. In other words the small-scale farmers continue to struggle to survive using the traditional adaptation techniques.

The study hypothesised that effects of climate change on small-scale farmers' livelihoods make farmers desire resources from the national park to meet their food and other needs. The study established that the small-scale farmers who reported that the effects of climate change led to desire of resources from the national parks were more likely to adopt 1-4 strategies (p=0.98) as opposed to those in reference category. However, this finding failed to reach statistical significance as p-value of 0.568 was greater than the alpha level of significance of 0.05. On the other hand, effect was found to be significant in the case of employing 5 strategies and above (p=.037). This means, protected areas are perceived as sources of many resources for farmers to meet their household needs. In other words, to stop and/or refrain from the extracting resources from the national park means adopting 5 and more coping strategies to substitute for the loss. This will include but not limited to water and soil conservation measures, expanding income base, off-farm opportunities. Expanded farm-to-farm extensions services will lend its self in this in bring new adaptation opportunities, facilities, information and support to the farmers. Properly packaged extension programme need to be prepared based on these findings and the on-ground prevailing conditions.

A relationship between main sources of income as influencing factor to adoption of coping strategies was analysed. Sources of income categorized into three namely crop farming, mixed crop and livestock and off-farming income. In the model, farmers who depended on off-farm income were in reference category. According to the dummy coefficients for crop farming and mixed crops with livestock were negative to the two models. This means that small-scale farmers who depended on the two forms of income sources were less likely to adopt climate change coping strategies than those whose sources of livelihoods were off-farm income. In the two models, this effect was found to be highly significant at 0.01. In other words, small-scale farmers that engage off-farm income sources better coped with adverse effects of climatic changes and variability than those who are dependent on farming suffer the brunt of climatic shocks and events such as drought, floods, pests and diseases. Off-farm activities provide income that meet household needs and has cushioning effect on negative climate change effects by using income from off-farm sources when agriculture is hit by climate change extreme weather events. It is a fallback (adaptation) position.

The study hypothesised that the frequency of listenership on climate change programmes on radio has influence on choice of adopting adaptation strategies. The study established that the farmers who pointed out that they listened to climate change adaptation programmes on daily basis were significantly more likely (p=.000) to adapt to employ the use of 4 strategies than those who never had such exposure. In other words, if one listens daily to radio on climate change issues, the probability to adopt mitigation strategies are higher than for those who did not listen on daily basis. The effect of radio listenership was however insignificant among those who reported listening to these programmes on weekly and monthly basis in the two models. Radios disseminate information to farmers, broker knowledge on climate change issues, enhancement of building resilience through awareness through the mass media and are farmers are likely to make considered decisions in climate change adaptation to tackle climate change effects. Nowadays, talk-shows on topical issues run on television and radios offer opportunities to anyone to call back and raise issues where clarifications are made hence subsequently guiding adaptation making decisions.

4. Discussion

The study showed that the small-scale farmers were aware of changes in climatic variables over the past twenty years. For instance, significant number of the respondents noticed rainfall change claiming that in spite of seasonal changes, the period under review more rainfall was received than before. Additionally, nearly over sixty percent indicated experiencing shorter dry spells, meaning there was increase in precipitation. These revelations in changes of seasonality in Uganda is consistent with UNCCP (2012), Christensen *et al* (2007) and IPCC (1996) whereby it is stated by the IPCC (1996) that eastern Africa will experience more rainfall than the rest of the continent. Increased rainfall is responsible for floods and soil erosion which affect crop production through mudflows, reduction of farm sizes and causation of rotting of tubers and roots, hence affecting crop production quantity and quality in the study areas.

Small-scale farmers noticed changes in temperature and perceived changes in the temperature variable. High temperatures are believed to be responsible for scarcity of rainfall and drought. The effect of drought on agricultural production was seen inform of high evaporation, loss of soil moisture, crop wilting, dying and increase in pests and termite attacks. These affect crop quality and leading to premature poor harvests thus food and livelihoods insecurity. This was prevalent more among the small-scale farmers in Karenga than in Kapchesombe. This finding is consistent with Nsubuga *et al* (2011) and Kagwa *et al* (2009) who found out that there were widespread temperature changes in Uganda and this already is taking toll on agricultural production throughout the country.

Precipitation throughout the country has been noted to be erratic and unpredictable with unclear onset and cessation. Small-scale farmers witnessed occurrences of extreme weather events in the past twenty years with increased frequencies. For instance, increased rainfall has effects of soil erosion, and flooding which affects agriculture. According to Okonya *et al* (2013) increased rainfall could affect the physiology of the crops and thus affect crop yields. On the other hand decreased rainfall causes loss of soil moisture, crop wilting and pests attacks leading to crop failure and poor rural livelihoods. This finding agrees with IPCC (1996) which predicted that while the rest of Africa will have drier spells, eastern Africa will have more precipitation inform of rainfall with frequent erratic weather and extreme weather events. Farmers need to develop appropriate changes in animal and crop husbandry and adopt the required and relevant adaptation technology to counter adverse effects of climate change.

The unpredictability of climate change in terms of weather patterns widely occurs in the country (Okonya *et al* , 2013; NCCP, 2012; GoU, 2010; GoU, 2007). The Small-scale farmers interviewed demonstrated through their responses to be faced with challenge of stressors (factors) such as diseases and pests, soil erosion, landslides and infrastructural failure arising from the unpredictable rainfall in terms of onset and cessation and frequent extreme weather events. Persistence on this undermines agricultural production and food security and is consistent with IPCC (2014) that states that based on many studies covering crops, negative impacts of climate change on crop yields have been more common than positive impacts (high confidence). Persistence of such stressors will require small-scale farmers to take on necessary changes in climate-smart agriculture (soil, crop varieties and water management) to address stressor effects in integrated manner. Government hand in supporting and strengthening the agricultural production assets in this regard is critical and imperative, given the agricultural sector contribution in GDP of the country. Agricultural experts need to be strengthened, equipped and motivated.

This study found out that over ninety five percent of the respondents' livelihoods are dependent on rainfall-pegged livelihood via rainfed agriculture. Persistence in this way of livelihoods drawing undermines effort to address vulnerability to adverse effects of climate change. The study revealed that very low and few activities had been started to increase household cash income and this included shop business, mixed-crop and livestock and salaried employment, thus leaving the majority still vulnerable to adverse effects of climate change. Improving base for off-farm activities for cash to off-set climate change induced hardship is imperative.

Rainfed agriculture is quite sensitive to even small changes temperature and rainfall (Okonya *et al,* 2013; IPCC, 2007). This study found out that nearly ninety six percent households interviewed experience food security problems due to climate change challenges whereby the reported the main causes being crop declines, decreased pasture lands and reduced water resources, critical factors in production assets. This finding is consistent with Assimwe and Mpuga (2007) who found out that Uganda' agricultural production is unstable because of dependence on rainfed agricultural production. The agricultural depend on natural weather patterns, so that variations in rainfall result in large variations in total output and farm incomes with effect on food security. In this study, climate change has affected all the four dimensions of food security: availability, accessibility, utilization and stability whereby most family misses out critical meals except for poor supper. The small-scale farmers are already vulnerable and food insecure and affected. This finding is consistent with FAO (2008) which stated that global climate change projections have solid scientific basis and there is growing certainty that extreme weather events are going to increase in frequency and intensity. With this has come the stressor factor, productive asset losses putting the small-scale farmers' food security in jeopardy. This case scenario was most felt in Karenga (lowland). Adaptation strategies that address food insecurity, pastures and water resources management should be those with sustainability component for posterity.

The small-scale farmers have coping strategies but need adaptation strategies for sustainability. Like elsewhere in Africa (Tafesse *et al,* 2013; Maponya and Mpandeli, 2012; Komba and Mchapondwa, 2012; Deressa *et al,* 2010; Fosu-Mensah *et al,* 2010; Gbetibuo, 2009; Nhemachena and Hassan, 2008; Okoye, 2008; Asiimwe and Mpuga, 2007) and the current coping strategies include: planting of different crops, use of different planting dates, plating different crop varieties and implementing soil and water conservation measures among others and the small-scale farmers are still vulnerable to adverse effects of climatic changes with low adaptive capacity. This is consistent with Gukurume (2013) and Shewmake (2008) who stated that small-scale farmers' adaptive capacity is usually low because of over dependence on natural resources, constraints in human and physical capital and poor infrastructure. In this study factors that hindered adaptation efforts were low farmers adaptive capacity, poverty and dependency on climate and weather resources (rainfed) agriculture subject to variations and poor human capital and inability to access adaptation technology. In addition, other constraints include lack of information, money, expertise, research and information gap, labour, complementary services and shortage of land. Addressing human capital and fixing productive assets is critical. Poverty eradication will enable farmers to pay for agronomic inputs and services. Integrated programme with early warning systems and weather forecasts and improved food storage and management and addressing the identified constraints need special attention. Effort to address farm-to-farm extension service is as well crucial to provide education, information, support to enhance efficiency of making adoption decisions in climate change mitigation among the small-scale farmers of Karenga and Kapchesombe.

It was observed that several factors influenced the probability of adopting adaptation strategies. It was noticed that agroecological zones had great influence in adoption of adaptation strategies. For instance, small-scale farmers in Kapchesombe (highland) were more likely to adopt adaptation strategies than their counterpart and this relationship was significant (p=.000) factor in predicting the likelihood of adopting adaptation strategies. The study established that small-scale farmers in highland area were more likely to adopt 1-4 strategies to adapt to climate change effects. In other words, individual from Karenga were more likely not to adopt any strategy as opposed to Kapchesombe. These results are in agreement with the t-test where on average, farmers in Kapchesombe had average of 6.6 adaptation strategies while Karenga farmers had 4.1 coping strategies. The probable reason for this could be because mountain ecosystems are sensitive to any slight changes in weather and climatic variable and farmers needed to be on top of the situation. But also, farmers of Kapchesombe could be less vulnerable with some abilities to access appropriate adaptation technology.

Gender analysis revealed that male were more likely to adopt 1-4 or above coping strategies as opposed to female. This finding is not consistent with Maponya and Mpandeli (2012) who found that female adapted more because of their long interaction with gardens whereby male usually go out to work in mines leaving women to fend for the family. However, this is not the case as the finding is contrary. This could possibly be because, the Karamojong and the Sabiny people are stratified along age and sex groups whereby men wield a lot of authority in household over the natural resources. But also, in modern times, men have access to loan, credit, banks, land and agricultural inputs which are critical production assets in agricultural production and therefore women are central and should be empowered to address climate change challenges for sustainable rural livelihoods development in Karenga and Kapchesombe. Women will take longer times in food gathering under the current situation of marginalization and disempowerment as climate change impacts livelihoods.

Obtaining support to address agricultural and climate change challenges was found to be insignificant factor in explaining the likelihood of adopting 1-4 or more coping strategies, thus creating a big surprise. This is not good at all because lack of access to credit, insurance loans, insurance and subsidies simply undermine the ability of the small-scale farmers to adapt to climate change. Kandlinkar and Risbey (2000) also found out that since most African farmers are operating under resource limitations such as lack of credit, subsidies and insurance, will limit their ability to meet critical transaction costs necessary to acquire adaptation measures as a result of an unexpected weather changes. Given the scenario, it's simply imperative for government to develop and provide comprehensive support to small-scale farmers (seeds, agrochemicals, and loan, credit and adaptation tools) not only to tackle climate change challenges but also to maximize agricultural output to alleviate household poverty. Otherwise, lack adoption of adaptation strategies. This result shows that, although the farmers who interacted with the extension staff were likely to adopt one or more adaptation strategies, compared to those in the base category, (who did not obtain support), the result however, show that the interaction was not statistically significant. This revelation is disturbing and not consistent with Nhemachena and Hassan (2008) who found out that better access to extension services has strong positive influence on the probability of adopting adaptation strategies and abandoning traditional husbandry. As Maponya and Mpandeli argue, the 4th Report of the IPCC (2007) is a wakeup call as the projected changes will be in temperature and precipitation and therefore information disseminated from extension staff is informative. This study contends that, such roles and responsibilities of the extension staff will provide critically needed information, education and awareness, institutional support and supplying farmers' need to adopt relevant productive and adaptive technology in the wake of adverse climate change impacts in Karenga and Kapchesombe.

Fulltime employment on the farm was a factor inversely (negatively) related with the choice of adopting 1-4 coping strategies and above. This implies that small-scale farmers working fulltime on their farms were more likely not to adopt adaptation strategies than the partially employed. This finding was significant in the case of employing 1-4 strategies. This finding is not in tandem with Nhemachena *et al* (2008) who established that fulltime farmers will not be affected much by climate change because they are aware of likely to have more information and knowledge on changes in climatic conditions. In this place, most small-scale farmers are migrants from elsewhere and therefore not fulltime. Also due to education needs, school going children are not at home to provide the labour. Extension role in role-model demonstration farms, awareness and support provision should be re-energized to empower the farmers.

Access to national park extractive resources as factor in predicting probability to influence adoption of 1-4 adaptation strategies revealed that small-scale farmers who accessed resources were less likely to adopt any adaptation strategies as opposed to famers who had no such privilege to national park resources. In spite of this finding, this factor was not a significant determinant in predicting the likelihood of choice of adoption of adaptation strategies. However, dependence on the resources from the national park is likely to impact negatively on the ecosystem health if extractive resources off-take is not well regulated.

Knowledge of the Uganda national climate change policy in the multivariate model was found to be a highly significant, with positive relationship was found for the dummy coefficients among small-scale farmers who reported having knowledge of the policy. This means that knowledge and information on the policy was a significant predictor for adoption of 1-4 and 5 strategies and above. In other words, having knowledge and information on climate change policy reduces the likelihood of not adopting any strategy. This is not surprising because policies set roadmaps where institutions and nations want to go and the Uganda national climate change adaptation policy has set priority adaptation and mitigation strategies and/or recommendations that every able bodied person is obliged to implement to tackle adverse impacts of climate change. These strategies are agricultural, agroforestry, land management and use, water use and sustainable management and sustainable business. This knowledge on the policy guides in rational decision making and adoption of optimal adaptation strategies to nutrilise adverse climatic change impacts.

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Income as factor to predict likelihood in adoption of strategies in this study did not support the assumption that a fall in household income plays a significant role in explaining whether the individual would adopt or not adopt any strategy. In other words, the level of adoption of strategies between those who have been affected and the base category (whose income not affected) is the same. In other words, those whose income has not been affected by climatic change have adapted although not to statistical significance. This finding is disturbing and not consistent with Lapar and Pandley, (1999) and Kurukulasuriya *et al.*, (2006) who found out that higher income and farm wealth inform of machinery and farm assets significantly and positively increased net farm revenue on African cropland. The above situation could be attributed to the high household poverty levels that cannot afford purchase of adaptation technology. In other words the small-scale farmers continue to struggle to survive using the traditional adaptation techniques.

The study hypothesised that effects of climate change on small-scale farmers' livelihoods make farmers desire resources from the national park to meet their food and other needs. The study established that the small-scale farmers who reported that the effects of climate change led to desire of resources from the national parks were more likely to adopt 1-4 strategies as opposed to those in reference category. However, this finding failed to reach statistical significance as p-value of 0.568 was greater than the alpha level of significance of 0.05. On the other hand, effect was found to be significant in the case of employing 5 strategies and above. This means, protected areas are perceived as sources of many resources for farmers to meet their household needs. In other words, to stop and/or refrain from the extracting resources from the national park means adopting 5 and more coping strategies to substitute for the loss. This will include but not limited to water and soil conservation measures, expanding income base, off-farm opportunities. Expanded farm-to-farm extensions services will lend its self in this in bring new adaptation opportunities, facilities, information and support to the farmers. Properly packaged extension programme need to be prepared based on these findings and the on-ground prevailing climate change conditions.

A relationship between main sources of income as influencing factor to adoption of coping strategies was analysed. Sources of income categorized into three namely crop farming, mixed crop and livestock and off-farming income. In the model, farmers who depended on off-farm income were in reference category. According to the dummy coefficients for crop farming and mixed crops with livestock were negative to the two models. This means that small-scale farmers who depended on the two forms of income sources were less likely to adopt climate change coping strategies than those whose sources of livelihoods were off-farm income. In the two models, this effect was found to be highly significant. In other words, small-scale farmers that engage off-farm income sources better coped with adverse effects of climatic changes and variability than those who are dependent on farming suffer the brunt of climatic shocks and events such as drought, floods, pests and diseases. Off-farm activities provide income that meet household needs and has cushioning effect on negative climate change effects by using income from off-farm sources when agriculture is hit by climate change extreme weather events. It is a fallback (adaptation) position.

The study hypothesised that the frequency of listenership on climate change programmes on radio has influence on choice of adopting adaptation strategies. The study established that the farmers who pointed out that they listened to climate change adaptation programmes on daily basis were significantly more likely to adapt to employ the use of 4 strategies than those who never had such exposure. In other words, if one listens daily to radio on climate change issues, the probability to adopt mitigation strategies are higher than for those who did not listen on daily basis. The effect of radio listenership was however insignificant among those who reported listening to these programmes on weekly and monthly basis in the two models. Radios disseminate information to farmers, broker knowledge on climate change issues, enhancement of building resilience through awareness through the mass media and are farmers are likely to make considered decisions in climate change adaptation to tackle climate change effects. Nowadays, talk-shows on topical issues run on television and radios offer opportunities to anyone to call back and raise issues where clarifications are made hence subsequently guiding adaptation making decisions.

5. Conclusions, recommendations and policy implications

The study investigated determinants influencing adoption of adaptation strategies and employed Multinomial logit (MNL) analysis based on success stories and relevant literature. It used several factors as determinants to predict the likelihood of adoption of adaptation strategies. These factors included: agro-ecological zone/location, gender, support obtained, interaction with extension staff, working fulltime, effect of natural hazards, access to natural resources, income to address climate change effects, desire of resources due to climate change impacts, sources of income and lastly but not least, frequency of radio listenership on climate change (which also formed the independent variables) and the set of adaptation strategies being the dependent variables. It was found that

that living in highland, being male, working fulltime, knowledge of the national climate change policy and experience of natural hazards and those that had off-farm income sources and frequency of listenership enhanced capacity of likelihood of choice of adaptation strategy due to merits they carry. In other words, using those factors enhance small-scale farmers adaptive capacity and will be better-off due to significant decrease in adverse impacts of climate change.

An approved mitigation and adaptation plan (sustainable climate change adaptation and livelihoods model) developed identified through this study need to be implemented, taking congnisance of the fact that climate change adaptation success is dependent on addressing the constrained identified, instituting working, dependable and adaptive extension service; women in Karenga and Kapchesombe need to be empowered and equipped with powers of decision making on land resources and agricultural development including access to agronomic inputs to address the current imbalance to tackle climate change and promotion of agricultural production. This means a broad-based agricultural modernization and climate change adaptation programme for Karenga and Kapchesombe at Subcounty level based on the findings of this study.

Institutional networking on climate change is paramount and information generation and sharing on status of seasonality and associated challenges, practical adaptation options, and information on agricultural husbandry relevant to improve and enhance adaptation effort need to be started. The role of the climate change secretariat is cardinal and central in this noble cause. The districts capacity in climate change mitigation is young and are heavily under-resourced as well lack the critical expertise. These need to be addressed with more resource support and capacity development.

Given that this is all happening at the door-steps of Uganda Wildlife Authority (UWA) estates of protected areas, UWA needs to develop comprehensive climate change adaptation programmes with research and livelihoods components fitting within the strategic national climate change policy and support the funding and institutional collaboration on this matter. Enhancing and supporting community adaptation should broadly look at agricultural and non-agricultural strategies that is climate-smart approach. Off-farm enterprises for alternative incomes could be explored and supported, in addition to provision of adaptation technologies.

At household level, every farmer needs to make and employ and implement strategies with respect to crop husbandry, soils and water management. Critical evaluation and opportunities to make changes in non-farm income sources need to be explored and talented farmers with entrepreneurial skills be supported to set up the enterprises. A fund therefore be established at district and devolved to Subcounty level in pilot areas for Karenga and Kapchesombe. In all this, small-scale farmers' abilities to tackle challenges of extreme weather events, effective extension service and obtaining of information; and accessing adaptation technology need to be integrated with awareness and indigenous coping strategies. Farmers should be encouraged to be broad-based as possible in climate change adaptation.

Future research direction

Future research should study in detail the following areas:

- Assessing the impacts of climate change on selected keystone species and rare wildlife species;
- Economic analysis of the impacts of climate change on small-scale farmers' livelihoods;
- Analysis of adaptive capacity of the small-scale farmers and their ability to respond to climate change effects.

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List of figures and tables

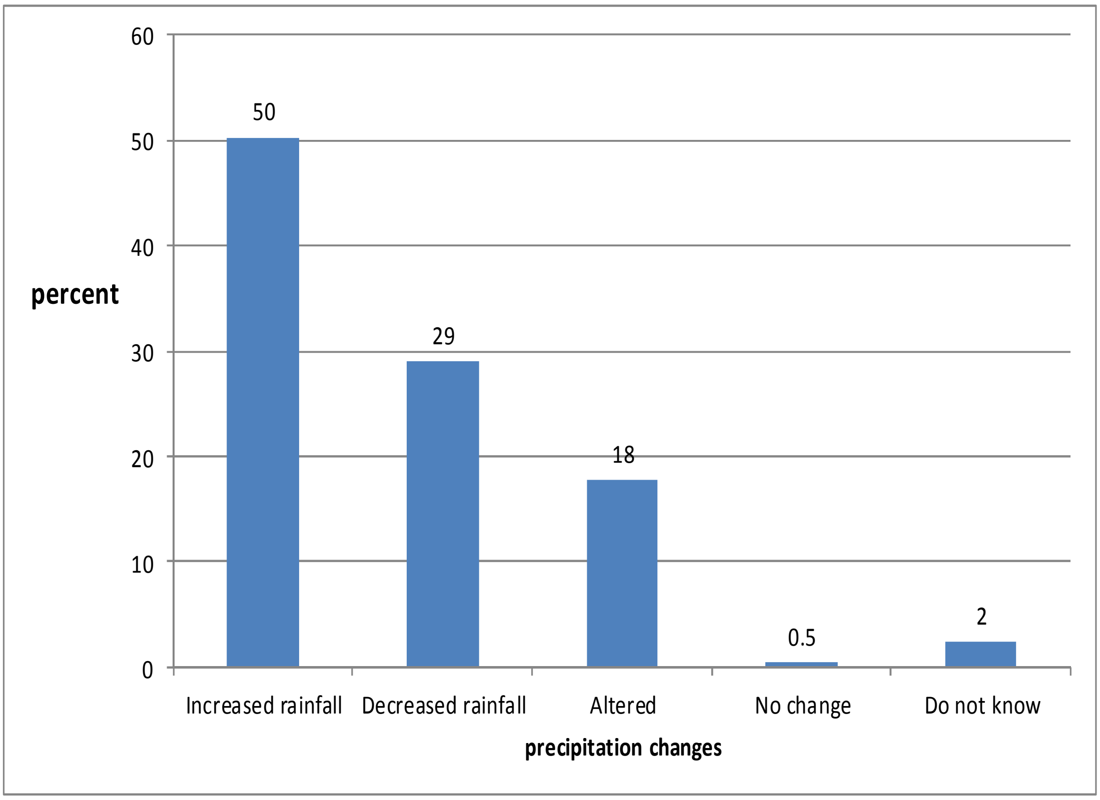

Figure 1 Level of change in precipitation over the past 20 years

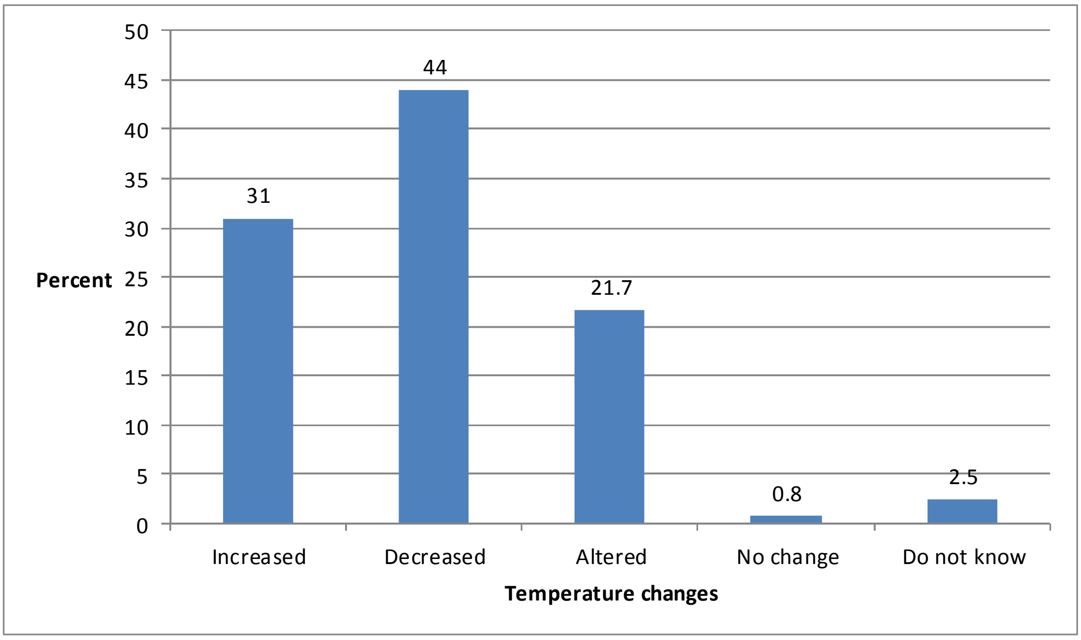

Figure 2 Level of change in temperature over the past 20 years

Table 1 Environmental effects of climate change in the area

Effects / **Variable**	Agro-ecology			
	Karenga (lowland)		Kapchesombe (highland)	
	Frequency	Percent	Frequency	Percent
Land conflicts	54	18.6%	8	3.5%
Reduction in agricultural output	230	79.0%	202	89.4%
Fall in household income	128	44.0%	14	6.2%
Disease outbreak	189	64.9%	11	4.9%
Destruction of the environment/soil	3	1.0%	6	2.7%
Water contamination	60	20.6%	1	.4%
Other	28	9.6%	4	1.8%

Table 2 Rainfall variability as major factor affecting household livelihood

Variable		Agro-ecology				Chi-square	p-value
		Lowland (Karenga)		Highland (Kapchesombe)			
		Frequency	**Row %**	**Frequency**	**Row %**		
Whether respondents believe that rainfall variability is the major factor affecting household livelihood?	No	20	23.0%	67	77.0%	34.450	.000
	Yes	276	57.1%	207	42.9%		
Total		**296**	**51.9%**	**274**	**48.1%**		

Table 3 How changes in climate affected crop production

Climate change event	**Effect on crop production**	**Crop affected**	**Percentage (%) households**
Storm (hailstorms & gales and strong winds	Shredded leaves, broken flowers and stalk, broken farm house and poor crop leaf quality	Cassava, pawpaw, sweet potatoes, bulrush, maize, sesame, beans, sorghum, sunflower, cabbages, lettuce, Irish potatoes & bananas	15.8
Changes in the onset and cessation of rain season	Reduced crop yield, poor grain quality, early late planting, crop wilt due erratic and early cessation of rainfall	Sorghum, beans, potatoes, cassava, groundnuts, bulrush, millet, maize.	09.1
Floods	Soil erosion, mudslides, reduced farmland and size, reduced yields, rotting of tubers and roots, outbreak of fungal diseases, blight, premature crop harvests, water logging, and crop destruction.	Sorghum, beans, pease, cassava, groundnuts, cabbage, Irish potatoes, water melon, wheat, barley, cow peas, sunflower, millet and simsim	19.2
Extreme/intensive & heavy rainfall	Soil erosion, cut-off access roads, reduced crop yields, rotting of beans, tubers and roots, crops unable to mature and dry well, poor yields and poor seeds and grain quality	Beans, sorghum, groundnuts, sweet potatoes and sunflower	16.9
Drought/prolonged dry spell and season	Crop wilt, crop failure, crop drying up, increased termite and insect pests attacks	Cow pease, groundnut, sorghum, sweet potato, maize, millet, soya beans, cassava, bulrush	35
Longer and more rainfall	Longer growing time and increased yields	Sweet potatoes, sorghum, maize, beans, cassava, groundnut, pease, garden pea, tomato, cow pea and soya beans	04
Total			**102**

The total is more than 100% due to multiple responses.

Table 4 Climate change and rainfall variability effects on household economy

Variable	Agroecologies				Chi-square	p-value
	Karenga		Kapchesombe			
	Frequency	**Percentage**	**Frequency**	**Percentage**		
Yes	194	63.8%	282	93.1%	79.221	.000
Slightly little	104	34.2%	17	5.6%		
Not at all	6	2.0%	4	1.3%		
Total	**304**	**100.0%**	**303**	**100.0%**		

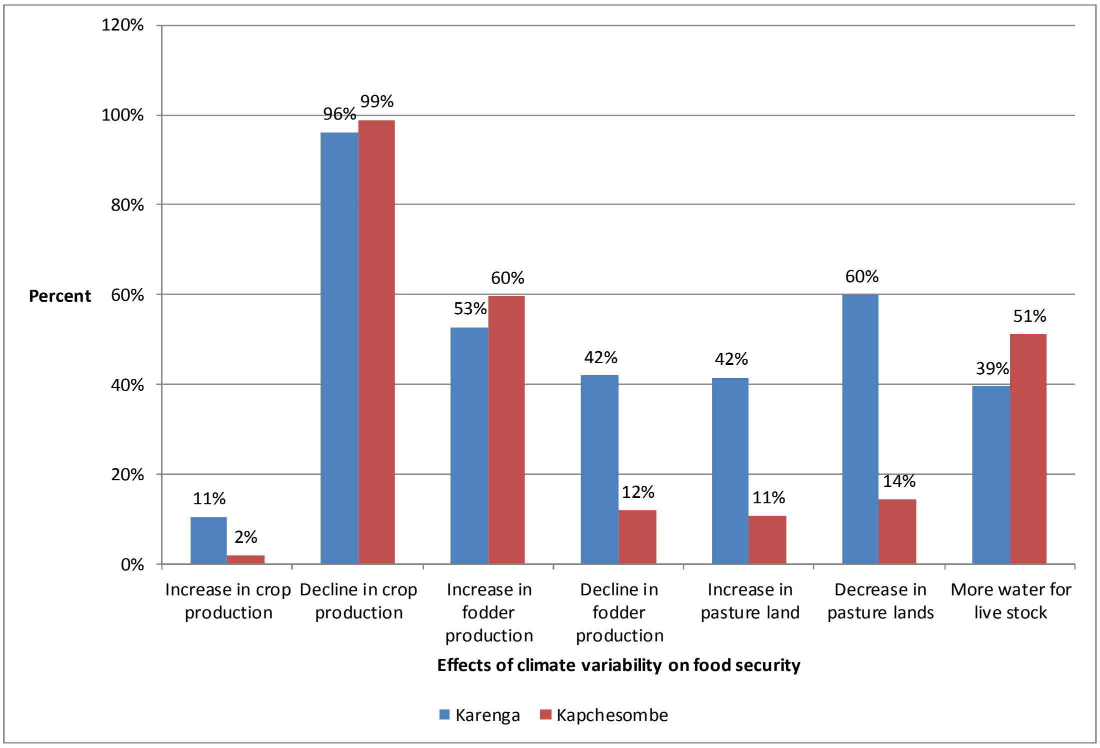

Figure 3 Climate change effects on food security

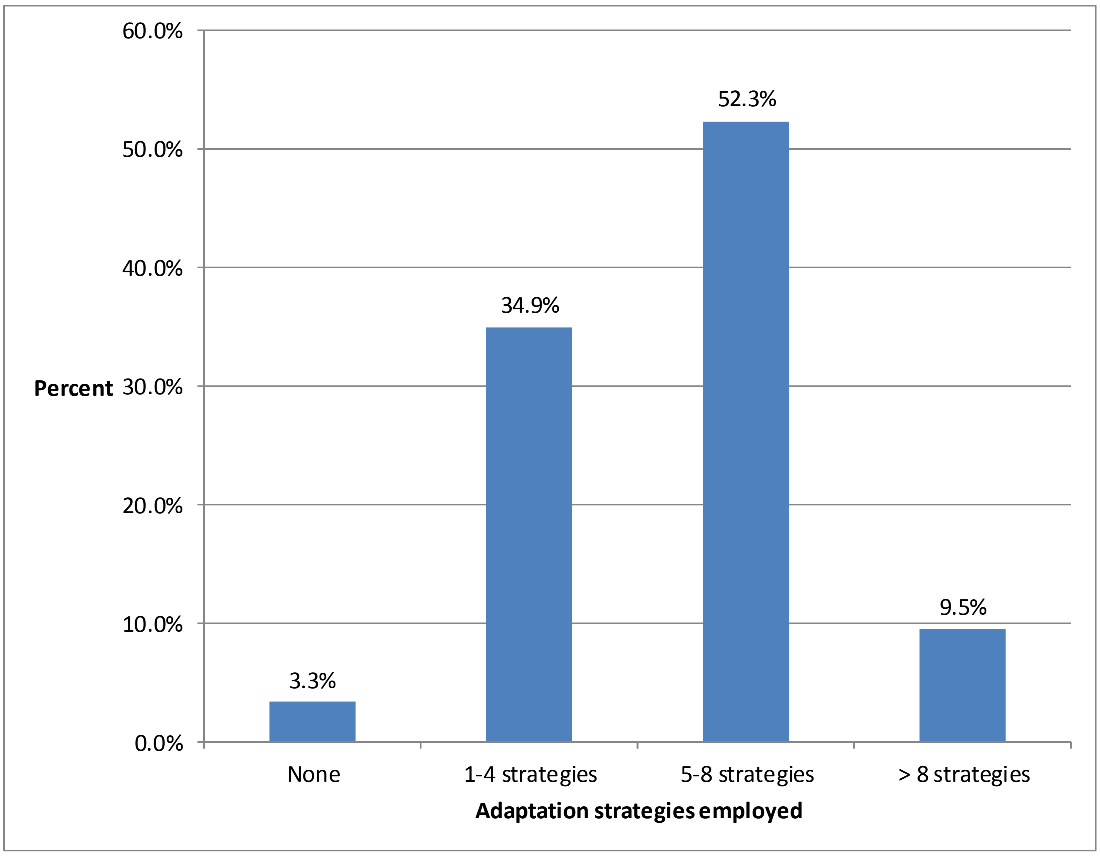

Figure 4 Adaptation strategies used to mitigate the impact of climate change by the farmers

Table 5 Coping and adaptation changes made in crop, water and soil management, past 20 years

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%

Table 6 Definition and notation of explanatory variables

Variable	Notation	Value/measure (dummy values)	Expected effect
Agro-ecological zone	zones	Binary (1 if adopt, 0 otherwise	±
Gender of respondent	Gender	1=male and 0=female	±
Support obtained	Support	1=yes and 0=no	+
Interaction with extension staff	extension	1=yes and 0=no	+
Working fulltime on farm	Work	1=yes and 0=no	+
Access to natural resources	resources	1=yes and 0=no	±
Heard of and know climate change policy	policy	1=yes and 0=no	+
Effect of natural hazards	hazards	1=yes and 0=no	+
Income to address climate change effects	income	1=yes and 0=no	±
Desire for resources from the park due to climate change	Resources from PA	1=yes and 0=no	±
Main sources of income	Income sources	1=yes and 0=no	±
Radio listenership	listenership	1=yes and 0=no	±