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SMALLHOLDER FARMERS' PERCEPTION AND ADAPTATION TO RAINFALL VARIABILITY IN MT. ELGON REGION, EASTERN UGANDA

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ABSTRACT

Rainfall is one of the most critical climatic factors for smallholder farmers in Uganda whose farming activities are dominantly rain-fed. However, changes in rainfall patterns are threatening these smallholder farmers' livelihoods. This study was conducted to appraise the farmers' perceptions about the changes in rainfall patterns and their effects on agricultural production and livelihoods in Bududa and Manafwa districts, Uganda. A descriptive study involving focus group discussions and semi-structured interviews was conducted to determine farmers' perceptions about the nature, effects and adaptation to changes in rainfall patterns. Results indicate that majority (98%) of the farmers had noticed changes in rainfall patterns. The seasons were reportedly becoming shorter due to late onset and early cessation of rains the amount of rain was also considered more than normal and was concentrated in a short period at the beginning or end of the season. Farmers' perceptions about amount of rainfall closely matched meteorological data. Results further show that farmers perceive that the shocks associated with changes in rainfall patterns result into reduced crop and livestock production as well depleting the livelihood assets on which they depend. Farmers do not perceive any opportunities presented by rainfall variability. Farmer households undertake different adaptation interventions individually and yet the covariate nature of the rainfall induced shocks and steep terrain in the area require these to be done collectively at landscape level for them to be effective. Therefore, more strategic and landscape level adaptation interventions that take into account farmers' knowledge and experiences are necessary.

Keywords: Smallholder farmers, rainfall variability, rainfall variability, agricultural production, livelihood assets.

INTRODUCTION

Smallholder farmers are sensitive to fluctuations and uncertainties of climatic conditions because of their sole dependency on rain as a key determinant of their livelihood. In sub-Saharan Africa (SSA) rainfall is the most important climatic parameter for smallholder farmers given that their farming activities are predominantly rain-fed (Cooper *et al.,* 2008; Alliance for a Green Revolution in Africa (AGRA, 2014). It is not only the amount of rainfall that matters but also its temporal and spatial distribution influence the planning and operations at the farm level. Stern & Cooper (2011) explain that mean annual rainfall determines the types of crops grown and livestock kept while rainfall variability determines the effective onset of the crop season, the timing, length and severity of dry spells during the growing season of cultivated crops. Even with the climate change phenomenon, the average annual amount of rain in most countries in SSA remains adequate for agricultural production (AGRA,2014) but most worrying is its distribution in the growing season. In Uganda for example, the average annual rainfall amount is about 1,318 mm, which is adequate to support agricultural activities (Kagwa *et al.,* 2009; Uganda Bureau of Statistics- [UBOS], 2015). However, the onset, cessation and distribution of rains during seasons have become unpredictable (Kagwa *et al.,* 2009; Mubiru *et al.,* 2012; Nandozi *et al.,* 2012; Caffrey *et al*., 2013; Kansiime *et al.,* 2013). The commencement of the first season in Uganda has frequently tended to shift from early March to late March or early April (Mubiru *et al*., 2012; Caffrey *et al*., 2013). Similarly, the frequency and severity of extreme rainfall related events such as droughts, heavy

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intensity rains, violent storms and hailstones has increased (Ministry of Water and Environment [MWE], 2007, Barihaihi, 2010). The steep terrain, high population density and severe degradation of natural resources in the Mt. Elgon area in Eastern Uganda exacerbate the risk of smallholder farmers. Any strategies to deal with the risks should rely on the perceptions of the farmers among other factors. The perceptions greatly influence the behavioral change to mitigate and adapt to the effects of climate change (Maddison, 2007; Bryan *et al.,* 2009; Deressa *et al.,* 2010). To cope with unpredictable rainfall patterns, farmers need to adapt their farming practices to sustain their production (AGRA, 2014). Maddison (2007) contends that farmers' can only adapt to rainfall variability if they perceive it as a problem and/or an opportunity.

Studies on rainfall variability and its impacts commonly apply crop-model simulations to recommend appropriate adaptation strategies (Simelton *et al.,* 2011) but such strategies may not be properly situated in the farmers' perceptions. Other studies (Kansiime *et al.,* 2013; Bomuhangi, *et al.,* 2016) have considered farmers' perceptions about rainfall variability for purposes of comparison with meteorological data as a check on validity of farmer perceptions. This paper therefore aims at exploring farmers' perceptions on rainfall variability in as far as it affects their agricultural production. Understanding these perceptions informs farmers decision making on adaptation measures and is also the core foundation for designing acceptable interventions to adapt to rainfall uncertainty (Gbetibouo, 2009; Osbahr *et al.,* 2011). Specifically, this paper; (i) Characterizes the normal rain season as perceived by farmers in relation to climatic data (ii) Describes the farmer perceptions towards the changes in rainfall patterns over the last 10 years (iii) identifies major climatic shocks and their effects on agricultural production and farmer livelihoods and (iv) identifies strategies used by farmers to adapt to the effects of changes in rainfall patterns.

METHODOLOGY

Description of the Study Area: Mt. Elgon area in Eastern Uganda is composed of eight districts namely; Mbale, Manafwa, Bududa, Sironko, Bulambuli, Bukwo, Kween and Kapchorwa. The area is characterized by steep terrain and a high population density (Mboga,2012). The high population density pushes people to cultivate on very steep slopes and other marginal lands. The mean annual rainfall for the area ranges from 1500 mm on the eastern and northern slopes, to 2000 mm in the southern and the western slopes and with a mean maximum and minimum temperatures are 23° and 15°C respectively (Mugagga *et al.,* 2012). Agriculture is the major source of livelihood with bananas, Arabica coffee and Irish potatoes being the major crops in the higher elevations while maize, millet, cassava, beans, sweet potatoes and vegetables are the dominant in the lower elevations (UBOS, 2010). The area however experiences severe soil erosion due the high amount of rainfall coupled with steep and intensively cultivated slopes (Jiang et al., 2014).

Research design: The study was conducted in Bududa and Manafwa districts. The two districts depict the demographic and biophysical features of Mt. Elgon area. A descriptive cross-sectional survey was conducted in June and July 2016 to gather data on occurrence, nature and effects of rainfall variability on agricultural production and livelihoods. The survey data was complemented with Focus Group Discussions (FGDs) aimed at obtaining in-depth understanding on; perceived changes in the timing of onset and cessation of rainfall seasons, distribution and intensity of rainfall during the season over the last 10 years.

Sampling and Subject Selection: Bududa and Manafwa districts were purposively selected as typical representatives of the Mt. Elgon agro-ecological zone. Through consultations with the production coordinators of the two districts, four sub-counties (Khabutoola and Nalondo in Manafwa district, Bushika and Nakatsi in Bududa district) that were considered to be the most affected in terms of damage caused by changes in rainfall patterns were purposively selected. Figure 1 below shows the location of the study districts and sub-counties (coloured red).

In each sub-county, three villages were purposively selected with guidance from the respective sub-county agricultural officers. The criteria for selection was experience of changes in rainfall patterns over the last 10 years with preference being given to the villages perceived by the respective sub-county agricultural officers as being most affected.

For FGDs, a total of 80 (40 males and 40 females) were purposively selected based on age, diversity of enterprises and recent participation in climate change related trainings/activities organized by the sub-county and/or other agencies of the government of Uganda. Farmers aged 40 years and above were preferred for FGDs because of their presumed experience and thus accumulated knowledge of the rainfall variability in their respective areas. On average, eight farmers were selected from each village to participate in FGDs. These were identified with guidance of the village local council chairperson, sub-county agricultural officer and chairperson of the sub-county farmers' organization.

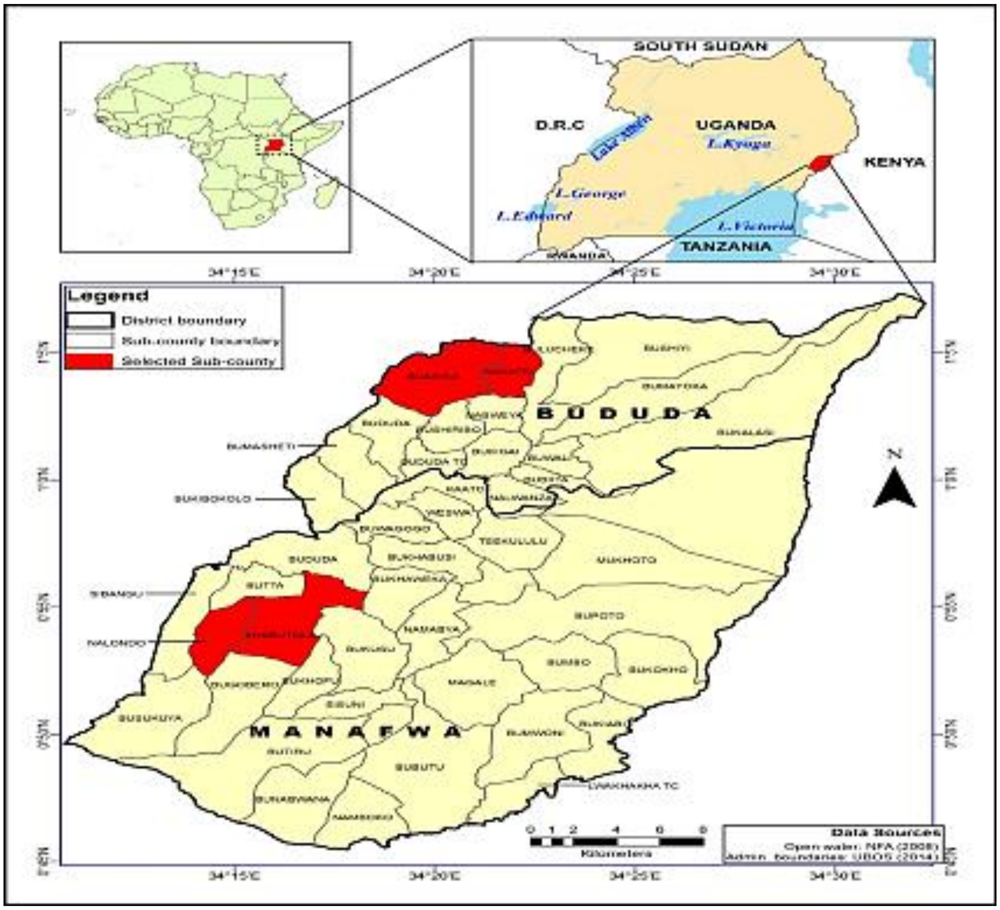

Figure 1. Location of study districts and sub-counties.

For the survey, the sampling frame comprised of lists of names of household heads in the 12 selected villages. These villages were purposively selected in consultation with the respective sub-county agricultural officers because they were the most affected by damages caused by changes in rainfall patterns. The lists were compiled by the respective village council chairpersons assisted by 2-3 other members of the village council. A total of 1,418 household heads were listed from which a sample of 127 household heads was obtained using the formula by Krejcie & Morgan (1970). The formula is as own below;

$$s = \frac{x^2 NP(1-P)}{d^2(N-1) + x^2 P(1-P)}$$

Where;

S is the required sample size

X^2 is a constant value of 3.841 (the square of the Z value of 1.96 for 95% confidence level)

N is the population size (1,418)

P is the population parameter of 0.9 (i.e. 90% of the households were farmers)

d is the 95% confidence interval (0.05), a probability that the sample represents the population.

The calculated sample size of 127 was increased by 10% to cater for non-response making the final sample size of 140 household heads. The number of household heads drawn from each village was then obtained through proportionate stratified random sampling. The number of households drawn from each of the villages is shown in Table 1 below.

Table 1. Number of respondents selected from each village.

District	Sub-county	Village	Total households	Sampled households
Bududa	Bushika	Bumushiso	119	12
		Lukongo	141	14
		Bunamumbya	132	13
	Nakatsi	Bushunya	79	8
		Lwangoye	84	8
		Bunambatsu	65	6
Manafwa	Nalondo	Kitsi	123	12
		Butsema	118	12
		Wanga	124	12
	Khabutoola	Busyula	216	21
		Watsube	89	9
		Bumurumu	128	13
Total			1418	140

Instrumentation and data collection procedures: Nine FGDs were conducted; three for women alone, three for men alone and three were mixed men and women. The FGDs captured data on farmer perceptions on types of shocks related to changes in rainfall patterns and their effects on farming. The FGDs were conducted in the local language (Lumasaba) and responses translated into English by a native Lumasaba speaker. Using participatory rural appraisal (PRA) tools, farmers visualized the monthly rainfall amounts in a comparative manner. They used stones to indicate amount of rain in the different months of the year with 0 stones for no rain, 1 stone for low amount of rain, 2 stones for moderate (adequate for planting) rain, 3 for more than moderate amount of rain, and 4 for extremely high amount of rain. The farmers discussed and agreed by consensus on the perceived amounts of rain for each month between 2013 and 2015. Farmers' perceived monthly rainfall amounts were only captured for the three most recent years (2013-2015) because that was the period for which farmers were able to clearly recall the rainfall patterns for each month. However, for the perceived changes in rainfall patterns, farmers focused on a 10year period (2006-2015). Figure 2 (a & b) show how the PRA sessions to capture farmers' perceived monthly rainfall amounts were organized and a sample of their outputs. For comparison purposes, rainfall data was obtained from Buginyanya meteorological station, which was the nearest weather station to the study area with complete monthly rainfall data for the three years that the study focused on. Information generated from FGDS was also used to develop specific follow-up questions for the survey. The survey questionnaire was used to collect data on individual farmers' perceptions of rainfall variability and its effects on their livelihoods for the past ten years. The perceptions were focused on; timing of onset, cessation, amount, and distribution of rainfall. Farmers perceptions were scored on a scale of 1 to 4. For timing of onset and cessation; 1= Earlier than normal, 2= Normal, 3= Later than normal, and 4=Variable. For amount; 1= Higher than normal, 2= Normal, 3= Less than normal, and 4= Variable. For distribution; 1= Heavier in the first month of the season, 2= Normal, 3= Heavier in the last month of the season, and 4= Variable. The items for scoring were checked for validity by two scholars from Makerere University. Prior to its use, the questionnaire was pre-tested on six farmers (not included in the study) to check for reliability. A Spearman Brown coefficient of the test-retest reliability was 0.8 indicating that the instrument was reliable. Nevertheless, the seemingly unclear questions were reframed before the final data collection tool was administered by trained enumerators.

Data analysis: Qualitative data from FGDs were analyzed using content analysis to identify the general patterns and categories emerging from the conversations. These were then used as anecdotal evidence to complement the quantitative data from the survey. Data from the survey was analysed using the statistical package for social sciences (SPSS) computer programme (version 21) to obtain frequencies, percentages and means. Principal component analysis (PCA) was performed to aggregate related effects and adaptation strategies mentioned by farmers. The PCA for effects and strategies generated a Keiser-Meyer-Olkin (KMO) sampling adequacy score of 0.569 and 0.575 respectively. These KMO scores were higher than the threshold of 0.5 implying that the data was valid for use to generate distinct and reliable factors (Field, 2009). All principal components that had Eigen values higher than one were considered as factors representing different types of effects and strategies.

Figure 2 (a). Farmers of Nalondo sub-county, Manafwa district indicating their perceived amount of rain per month in one of the PRA sessions.

Figure 2 (b). A sample output from the PRA sessions showing farmers' perceived rainfall amount per month for 2015.

RESULTS AND DISCUSSION

Table 2. Farmers' socio-economic and demographic characteristics.

Socio-economic Characteristics	Categories	Percentage
Sex of the respondent (%)	Male	64.4
	Female	35.6
Household type	Male headed	83.1
	Female-headed	16.9
Highest level of education attained by any h/h member	No formal education	3.5
	At least Primary	48.8
	At least Secondary	38.3
	Post-secondary	9.3
Group membership	Membership to groups (at least a membe of the household belonging to group)	58.2
Farmers who have accessed credit in the past one year		20.0
Farmers who have accessed scientific climate forecasts in the past one year		84.4

Farmers' socio-economic and demographic characteristics: The males (64%) were more than females because the sample was based on household heads. It is common that men in most communities are considered the household heads, though this may not necessarily reflect a share of responsibility in the household. The education levels within a household are indicative of the appropriate means for accessing weather related information and its potential use. Whereas nearly half (49%) of the respondents had attained at least primary education, the other half had at least Secondary education and above. This indicates that at least half of the respondents could read and interpret the weather-related information if channelled through print media. About 58% of the households had one or more members belonging to a farmers' group – indicating the networks that can be used for learning and adaptation to changing patterns of rainfall among other things exist. Access to credit and climate information services are key in enabling farmers to cope with and adapt to climate change and variability (Deressa *et al.,* 2010). Only 20% of the respondents reported having obtained credit to invest in their agricultural activities in the previous year. About 84% of the farmers had received one or more types of scientific climate information in the last one year.

Description of the farming system: Farmers involved in the study were typically smallholder farmers engaged in both crops and livestock farming. Table 3 below indicates some of the basic characteristics of the farming system. Typical to smallholder farming, the households engaged in multiple enterprises including cash and food security crops, livestock and poultry. Bananas and coffee were the most commonly grown perennial crops often intercropped with beans and maize. Beans and maize were grown by more than 90% of the households for food security and excess for sale. The average farm size was 3.5 acres. About 2.9 acres of the total farm land (74%) was on steep slopes, posing challenges of natural resource management such as erosion and risks to livelihood such as landslides. Because of the limitation of farm lands, most of the livestock was reared in small numbers and often on zero grazing system where the animals are stall fed. The livestock was basically reared to supplement household nutrition and for income security. Agriculture was the main source of livelihood for most of the households including selling of labor to other farms. Households had an average of about one off-farm income source with the common options including brick making, stone quarrying and sand mining from rivers. The low number of off-farm income options indicates that the livelihoods of the households in the area are strongly dependant on agriculture. Therefore, changes in rainfall patterns are a key threat to the livelihoods of the farmers residing in the rural area.

Table 3. Description of the farming system in the study area.

Characteristics	Categories	Percentage	Mean
Type of Crops	Beans	93.6	-
	Maize	92.4	-
	Bananas	72.8	-
	Coffee	64.8	-
	Cassava	35.7	-
Type of livestock	Chicken	75.7	-
	Cattle	67.1	-
	Goats	54.3	-
	Pigs	18.6	-
	Sheep	2.9	-
Total land accessed	Acres	-	3.5
Land on steep slopes	Acres	-	2.6
Land in flat areas	Acres	-	0.9
Number of off farm income sources	Number	-	1.4

The farmer perspective of normal rainfall patterns: Changes in rainfall patterns was in reference to what farmers considered to be the normal pattern. Farmers characterize normal rainfall pattern by the timing of onset and cessation for the two growing seasons and the distribution and intensity of rain over the year. Figure 3 illustrates the normal seasons as perceived by farmers.

Rainfall pattern in Mt. Elgon region is bimodal with the main rain season being March to May and the other rainy season from September to November (also see Mbogga, 2012). The farmers' perceptions of a normal season influence their planning of agricultural activities. Deviations from the normal therefore often negatively affect the farm operations and hence livelihood. In terms of pattern over the last three years (2013-2015), there is a close relationship between the famers perceived amounts of rainfall received with the -actualmeteorological datafor the two seasons as illustrated in Figures 4a, 4b and 4c. This indicates that, although farmers do not keep records of amounts of rain received, their estimates based on experience closely corroborate with the meteorological data. Similar experiences are reported by Simelton *et al.* (2011) and Bomuhangi *et al.* (2016). The slight differences between farmers' perceptions and meteorological data for some of the months could be due to the differences in location of the participating farmers and the non-location specific nature of meteorological data. Contrary to what many scientists believe that farmer perceptions are not factual, they can closely represent scientific facts and could be relied on for evidence-based decision-making. This is critical especially in situations where location-specific meteorological data is not available or even where the meteorological data may not be reliable for several reasons including breakdown or inaccuracy of equipment used.

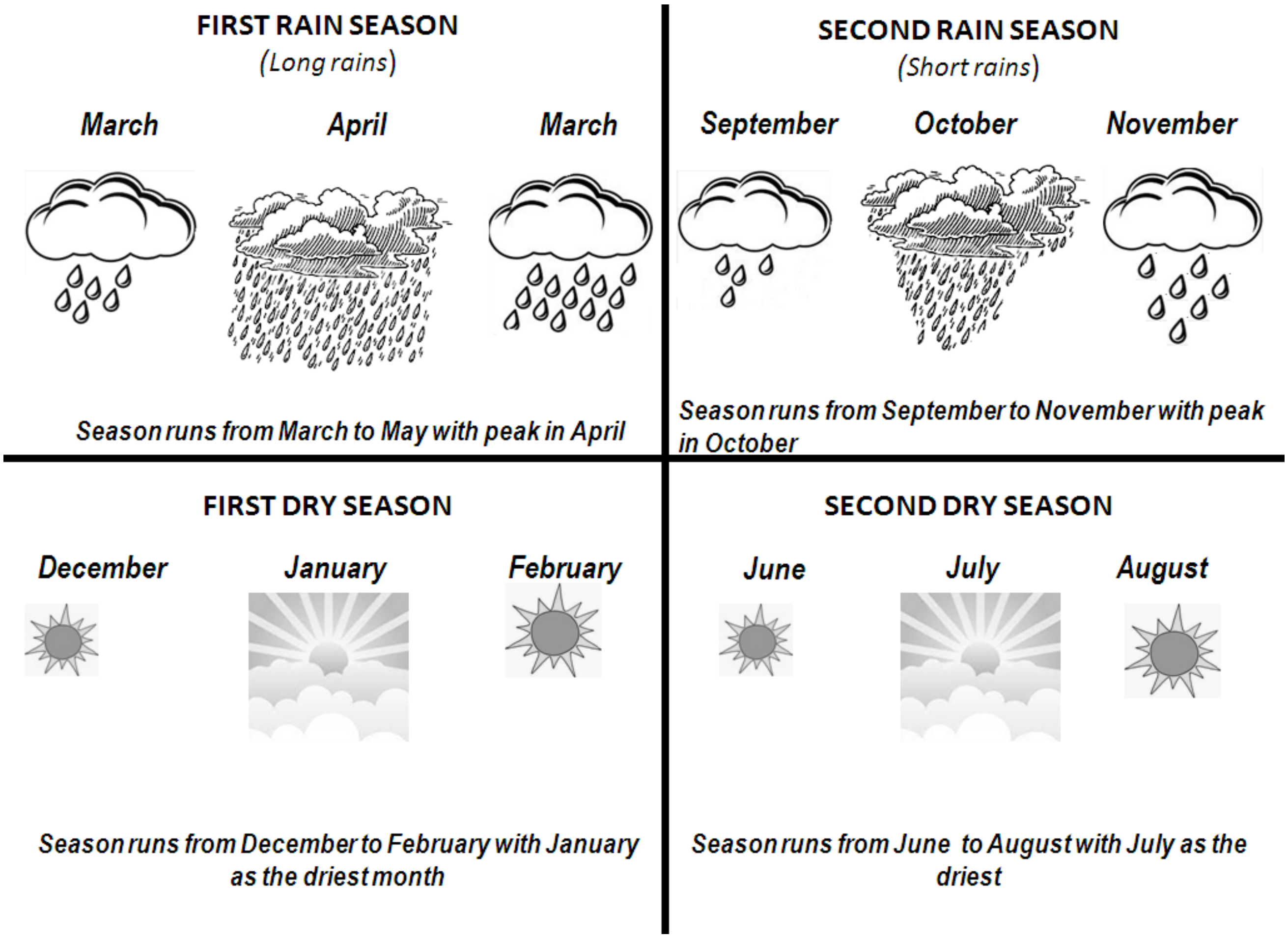

Figure 3. Perceived normal seasons in Mt. Elgon area.

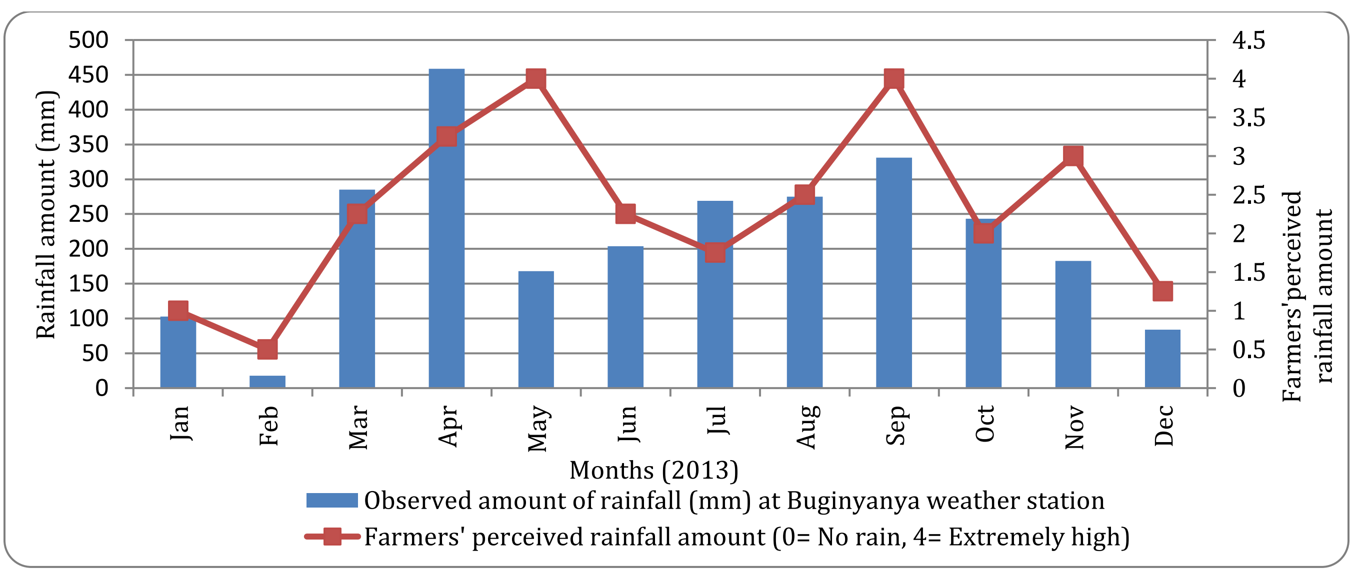

Figure 4 (a). Comparison of farmers' perceived rainfall amount against meteorological data (2013).

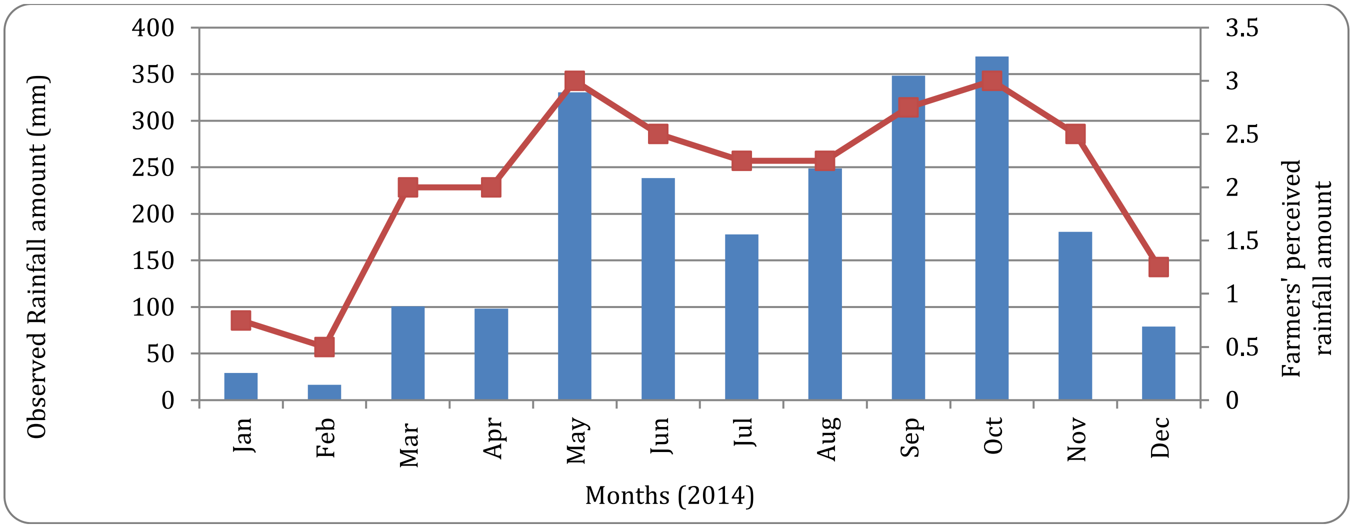

Figure 4 (b). Comparison of farmers' perceived rainfall amount against meteorological data (2014).

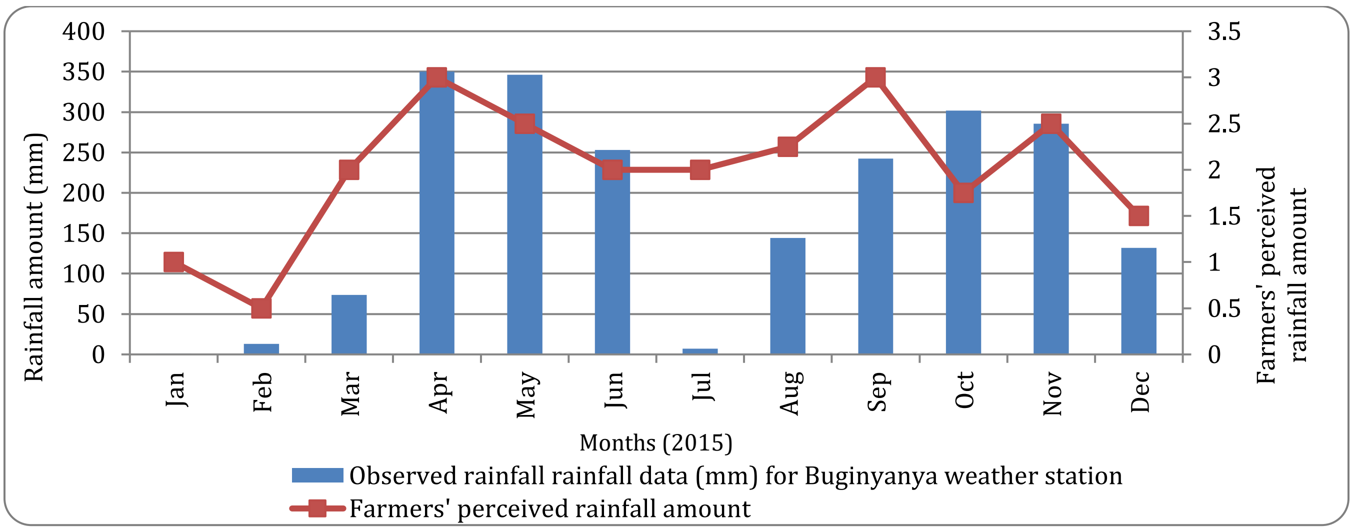

Figure 4 (c). Comparison of farmers' perceived rainfall amount against meteorological data (2015).

Trend of rainfall patterns in the Mt. Elgon Zone: The majority (98%) of the respondents acknowledged changes in the rainfall patterns (deviation from the normal) over the past ten years (2006-2015). These changes manifested in form of (i) timing of onset and cessation of rainfall seasons; and (ii) the amount and distribution of rainfall. Timing of onset and cessation of rains are critical to guide decisions on what crops to grow (especially for the annual crops) and when to plant. Timing of onset determines when and whether farmers should sow their crops while timing of cessation determines how long the growing season will be and thus the possibility of a failed or good season (Stern & Cooper, 2011). Figure 5 presents farmers' perception of the deviations from normal with regard to onset and cessation of rains over a ten-year period.

Majority of farmers perceive a tendency for the onset of rains to be coming later than expected (mid-March) and yet it ceases earlier. This implies shortening growing season than normal. An equal number (17.5%) think the onset of rains is earlier than expected or unpredictable. Similarly, 23% and 20% of the respondents thought that the rains tend to cease earlier or as expected (normal) respectively. Whereas this may be interpreted as mixed feeling among farmers, in the past ten years, the majority clearly observes a tendency towards shorter growing seasons than normal (also see Mbogga, 2012; Mubiru *et al*., 2012; Kansiime *et al.,* 2013; Bomuhangi *et al,* (2016). These changes in the timing of onset and cessation of rains have altered farmers' agricultural calendars.

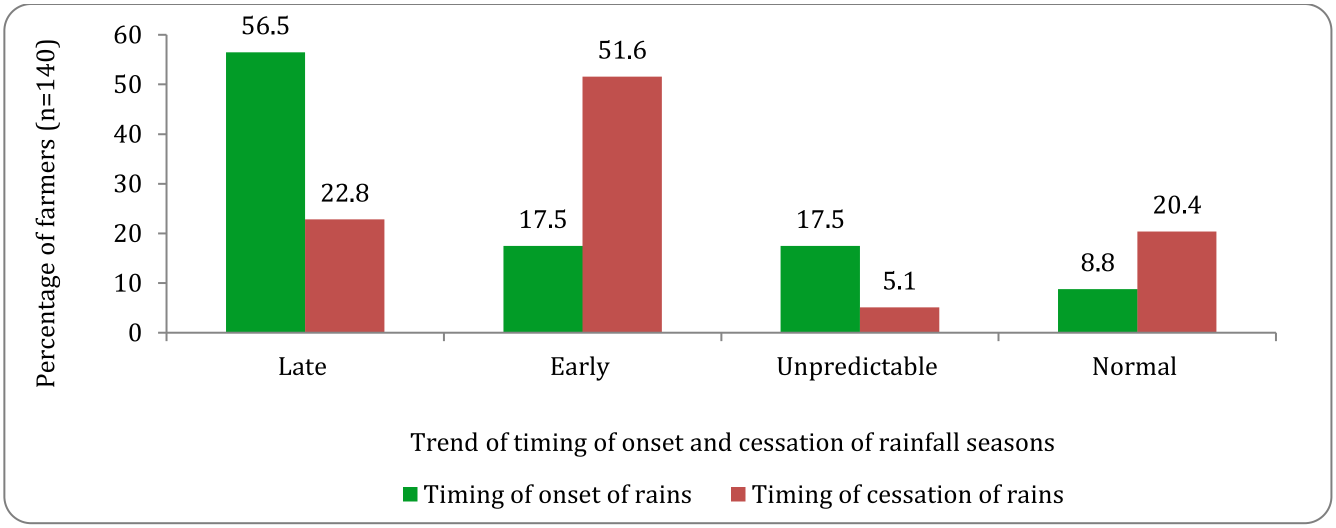

Figure 5. Farmers' perceived changes in the timing of the rainfall seasons (2006-2015).

For instance, a farmer in Kitsi village, Nalondo sub-county, Manafwa district, testified:

> *Previously we knew rains normally started in February but now, they start in April. This trend started in 1984 and it has become even unpredictable over the years. This phenomenon has seriously affected our agricultural activities. Currently, we do not have a clear indication of when to plant; we plant in phases whenever the rains appear* (FGD in Manafwa district 23 March 2015).

This change in seasonality has implications on the coping and adaptation strategies for the farmers as they do not seem to have alternative livelihood options. Only about 9% and 5% of the respondents thought the onset or cessation of rains remained normal respectively over the past ten years. Stern and Cooper (2011) however argued that the timing of onset and cessation of rains only indicate the length of the growing season and not the occurrence and severity of dry spells during the rain season and yet these are also important considerations for farmers. Therefore, this study also investigated farmers' perceptions about changes in the amount and distribution of rainfall for the same period (2006 to 2015) (Table 4).

Table 4. Perceived changes in amount and distribution of rainfall, 2006-2015.

Attribute	Categories	Percentage of farmers
Amount of rainfall	More than adequate	50.4
	Inconsistent/unpredictable	22.6
	Normal	19.0
	Less than adequate	8.0
	More concentrated in the first part of the season	41.6
Distribution of rainfall in season	More concentrated in the second part of the season	29.9
	Inconsistent/unpredictable	16.8
	Normal	6.6
	Dry spell interspersed within season	5.1

At least half of the respondents perceived the amount of rainfall received in the last 10 years to be more than adequate. This means that the trend is towards more intense rainfall in a shorter period of time than before, also posing another risk of floods and sometimes landslides in the steep slopes. Bomuhangi *et al.* (2016) reported noticeable increase in the amount of rainfall received in the September to November period compared to the long-term average for the same period in the Mt. Elgon area. About 42% of the respondents think the rains tend to be more concentrated in the first half of the growing season although about 30% of the respondent thought it was the reverse. Either way, this is recipe for crop failure and other disastrous effects such as severe erosion and landslides which also reduces the sustainability of the natural resources for crop production. For annual crops such as beans and maize, heavy intensity of rain in the second part of the season exacerbates the postharvest losses since farmers rely on sunshine to dry their crop produce. Post-harvest losses are even more costly to the farmers since they will have already invested a lot (in terms of inputs and time) up to the maturity of the crop. In attempt to avoid the post-harvest losses due to intense rainfall in the second half of the growing season, farmers sometimes harvest crops such as beans and ground nuts before they fully mature and shade-dry them on their verandahs (figure 6). This kind of drying is however possible only for small quantities. This also downgrades the quality of such crops in addition to other potential risks such as afflatoxins contamination as reported by Caffrey *et al.* (2013).

Figure 6. Shade Drying of Beans.

Shocks associated with changes in rainfall patterns: Changes in rainfall patterns can trigger different shocks that can have various adverse effects on farmers' livelihoods. Approximately, 90%, 72% and 66% of the farmers mentioned heavy intensity rainfall, drought and hailstones respectively as the major shocks resulting from rainfall variability. Further, more than half of the farmers noted that heavy intensity rainfall triggered secondary shocks notably landslides in the steep slopes and floods in the lowlands and valleys. Earlier studies by MWE (2007) and Kansiime *et al*. (2013) reported similar incidences of heavier intensity rainfall in Mt. Elgon area. The International Disaster Database further points out five episodes of floods and land/mud slides in Mt. Elgon area between 1997 and 2011 (EM-DAT, 2016). Meteorological data however indicates that the Mt. Elgon area had not experienced a drought over the last 10 years. Therefore, what farmers refer to as drought may be simply longer dry spells also alluded to by Mbogga (2012) due to shortening of the duration of rains.

These shocks have effects on agricultural production and farmers' livelihoods. Farmers mentioned 15 specific effects on their livelihood or farming. These were aggregated using Principal Component Analysis (PCA). Only six principal components (factors) that had Eigen values of more than one (Field, 2009) were considered. These factors generated extracted approximately 62% of the variance that existed.

Factor 1 accounted for approximately 14% of the variance, Factor 2 for 12%, Factor 3 for 11%, Factor 4 for 10%, Factor 5 for 8% and Factor 6 for only 7%. Table 5 below shows the specific effects and the components on which they loaded highest. The specific effects that loaded highest onto a component were the basis for assigning the labels to the respective components as shown in Table 5.

Because agriculture is central to farmers' livelihood, reduced crop production was the most serious effect from all rain-induced shocks. The reduction of crop production is through soil erosion and crop failure due to prolonged dry spells and higher build-up of pest and diseases. The reduction in crop production translates into difficulties in accessing food of adequate quality and quantity. This then leads to depletion of other capitals especially financial, human and social. Financial capital is depleted as a result farmers compelled to purchase food at high prices and sell their livestock at low prices to obtain cash to buy food. Social capital is also depleted as a result of reduction of crop production as people (especially males) have to temporarily migrate in search of alternative employments elsewhere in order to provide food and other non-food basic needs for their households. Most of the other effects including depletion of human and physical capitals were especially associated with heavy intensity rainfall that triggered landslides and floods that killed people and destroyed infrastructure such as houses, schools, health facilities and roads. The landslides and floods also contaminated water sources leading to prevalence of water borne diseases. Reduction in livestock production was more associated with the drought unlike other effects that seemed to be triggered by heavy intensity rainfall. Farmers noted that the drought resulted into drying of pastures and fodder and increased prevalence of livestock diseases.

Table 5. Effects of rainfall induced shocks on agricultural production and farmers' livelihoods.

Principal components & their constituent variables	% of farmers mentioning effect against the rainfall variability shocks			Component loading
	Heavy rains (n=126)	Drought (n=101)	Hailstorms (n=93)	
Depletion of financial capital				
Increased food prices	24.5	25.5	14.3	0.690
Death of livestock	26.6	4.1	9.7	0.804
Low livestock prices	7.8	11.4	7.5	0.604
Reduced crop production				
Destruction of crops	100.0	19.4	88.2	0.575
Soil erosion	68.8	0	12.9	0.696
Drying crops	0	79.4	0	0.494
Crop pest & Diseases	5.5	23.8	4.3	0.481
Depletion of physical and social capital				
Collapse of farm structures & houses	49.2	0	24.7	0.791
Migration	18.0	0	0	0.739
More difficulties in food access & preparation				
Reduction in quantity & quality of food	38.6	31.6	8.6	0.798
Lack of firewood	9.3	0	2.5	-0.660
Reduced livestock production				
Drying of pastures and fodder	0	33.9	0	0.716
Livestock diseases	7.8	12.6	4.3	0.524
Depletion of human capital				
Death of people	35.2	1.0	4.3	0.529
Prevalence of water borne diseases	12.5	0	0	0.800

The types of effects as described above are a reflection of farmers' dependency on rainfall and other natural resources for their livelihoods. The effects of the climatic shocks especially compromise farmers' capacity to sustain their livelihoods under the current and future climatic conditions through depleting the different kinds of financial, social, physical and human capitals available to the farmers. Surprisingly, none of the of the farmers mentioned any opportunities yet physical observations in the study area indicated some opportunities brought in by rainfall variability and farmers were already harnessing them. For example, run-off resulting from heavy intensity rainfall had transported substantial amounts of stones, aggregates and sand from the hill slopes to low lying areas from where farmers were already accessing them for own use and sale. Our findings about the effects of climatic shocks are consistent with Barihaihi (2010), Hepworth, 2010, Caffrey *et al.* (2013). For instance, a review of literature on common climate-related disasters in Uganda by Barihaihi (2010) found out that climatic shocks had led to crop failure that had triggered food insecurity, increased food prices and general decline in people's welfare. According to Bryan *et al*. (2009), the diverse nature of the effects of climatic shocks require use of multi-faceted approaches involving various actors and stakeholders in order to enable farmers sustain their livelihoods now and in the future.

A key starting point for these actions within the agricultural sector should involve first understanding what farmers as the primary victims of the adverse effects of the climatic shocks are doing in a bid to cope with and adapt to the situation. The next section explores the strategies that farmers used to cope with and adapt to the effects of the shocks associated with rainfall variability.

Adaptation strategies to the effects of rainfall-induced shocks: The farmers react to the shocks explained above with some strategies to cope with the effects. Some of these strategies are on-farm while others are off-farm. The strategies were clustered into four major categories using PCA. The decision to aggregate the strategies into four was based on the focus group discussions where farmers indicated that a single farmer on average was unlikely to apply more than four different strategies. Table 6 shows the Eigen values and the percentage of variance extracted by each component.

Table 6. Principal components for adaptation strategies to effects of rain-induced shocks.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
Crop intensification and agro enterprise diversification	2.181	14.542	14.542
Migration	1.962	13.080	27.621
Soil nutrient & water management practices	1.540	10.265	37.886
Stabilization of income and food availability	1.365	9.100	46.986

Keiser-Meyer-Olkin (KMO) sampling adequacy score= 0.575

The four factors extracted by PCA explained approximately 47% of the variance. Factor one extracted the highest variance and the others followed closely. The low variances extracted by the different factors shows the diversity of the adaptation strategies used by the different farmers. Each of the factors was assigned a label based on the specific adaptation strategies that loaded highest onto it. Table 7 below indicates the loadings and frequencies of the specific strategies that constituted each factor.

Table 7. strategies for coping with effects of rain-induced shocks.

Principal components & their constituent variables	% of farmers mentioning strategy to cope with/adapt to effects of the rainfall variability shocks			Component loading
	Heavy rains (n=126)	Drought (n=101)	Hailstorms (n=93)	
Crop intensification and agro enterprise diversification				
Practicing intercropping	4.6	8.0	2.1	0.916
Use of manure	4.6	1.0	0.0	0.812
Practicing crop rotation	1.5	3.5	0.0	0.725
Using narrower than recommended crop spacing	2.4	6.8	1.1	0.698
Adopting improved seeds	0.8	5.0	2.1	0.561
Integrating livestock and crops	3.1	5.0	1.1	0.536
Growing food security crops	5.3	6.2	1.1	0.528
Early planting	4.5	5.9	5.3	0.522
Taking up new crops	1.5	3.0	4.2	0.511
Establishing grass strips	7.6	0	1.1	0.482
Migration				
Temporary migration	48.1	1.0	5.3	0.788
Long-term migration	16.7	0	1.1	0.701
Soil nutrient & water management practices				
Tree planting	35.1	5.0	26.1	0.819
Construction of SWC structures (terraces/trenches)	45.0	0	6.3	0.745
Mulching and cover crops	12.9	4.0	3.2	0.595
Stabilization of income and food availability				
Hiring out labour	10.1	30.7	28.3	0.644
Starting off-farm businesses	12.2	18.8	12.2	0.597
Storing food for unpredictable times	6.9	20.8	9.5	0.526
Growing drought resistant varieties	0	10.9	0	0.512
No strategy	30.5	15.8	40.0	

The main strategies for coping with effects of rainfall-induced shocks include; crop intensification and agro-enterprise diversification, migration, soil nutrient and water management practices, stabilization of income and food availability. Although intercropping, as an element of crop intensification has been part of the smallholder farming system for much longer than we have known about climate change, it is perceived to be even more important now than ever before. It is a risk management strategy to guard against situations where some crops may completely fail due to differential tolerance to inadequate rains or even too much rains.

The use of manure to enhance soil productivity and other soil management practices like crop rotation are now deliberately and consciously practiced by the smallholder farmers. In this regard, integration of livestock and crops becomes a strategy not only to diversify farm enterprises but also to provide the most needed manure for the crops (especially the high value crops). Use of improved seed that has been bred with more tolerant attributes to adverse weather conditions and yet yields more than the local seed is now common practice and part of the crop intensification strategy.

In extreme cases of more than normal rains, the farmers especially those on steep slopes are prepared to temporarily relocate (migrate) to safer places as the situation normalizes. Migration as an adaptation strategy is attributed to the fatal nature of some of the secondary shocks such as landslides and floods, which are triggered by heavy intensity rains. About 48% of the farmers who had perceived heavy rains as shock in their communities planned for possible temporary migration and about 17% anticipated long-term migration as a possibility. These migrations were not common in the past but with the recent landslides resulting from a combination of factors including too much rains and destabilization of the land cover on the slopes of Mt. Elgon, migration has become common and is now anticipated by farmers. The effects of changes in rainfall patterns have therefore caused a shift in the mindsets of the farmers to be prepared for change in socio-cultural context that is usually associated with migrations. Government of Uganda through the Department of Disaster Preparedness (DPD) and other development agencies have since the fatal landslides in 2010 been encouraging and facilitating migration especially for farmers located on steep slopes as an adaptation strategy. Farmers are now more aware of the need to undertake better soil and water management practices, not only to conserve the soil moisture to support plant growth during prolonged dry spells but also to guard against enormous soil erosion during more than normal rains. Of the farmers undertaking this strategy, 45% construct terraces and trenches while 35% have increased tree planting as an environmental management practice. Although such practices would have greater impact when undertaken at landscape level, at the moment they are undertaken at farm level and depending on the consciousness of the farmer. The risk is that even the farmer who undertakes these practices will be affected (depending on their location in the landscape) if his/her neighbors do not undertake similar measures. While there is empirical evidence that soil and water conservation technologies can significantly reduce production risk associated with climatic shocks (Kato *et al*., 2011) their effectiveness depends on widespread use (Food and Agriculture Organization [FAO], 2014). It has to be undertaken as collective responsibility as opposed to current individual undertaking. Based on this study, only about 55% of the farmers were practicing any soil nutrient and water management measures despite awareness of the importance of such practices in the area.

Stabilization of income and food availability is mainly through exploring off-farm income sources including hiring out labour, general merchandize shops, trade in agricultural produce, brick making, stone quarrying and sand mining. Farmers appear to be conscious about storing food for a longer period (a month or more) because of the unpredictability of the next growing season due to droughts or hailstorms. However, few of them are doing so possibly due to low production that translates into limited quantities being available for storage. Hiring out labour has been reported as a coping strategy for different climatic shocks and impacts (Rwenzori Think Tank, 2011; Caffrey *et al*., 2013).

Over 44% of the farmers did not mention any deliberate adaptation strategy to cope with the effects of changes in rainfall patterns though they acknowledged experiencing the shocks. For instance, 40% and 22% of the farmers that reportedly experienced hailstorms and heavy intensity rainfall respectively did not have any adaptation strategy. In the FGD in Bududa district, a farmer stated; *We know that whenever rains delay to come, they are most of the times followed by hailstorms, but there is nothing we can do to prepare for the hailstorms because our crops are grown in the open, may be you (researchers) can tell us what we should do* (Male-Based FGD, Bushika sub-county, Bududa district 24 March 2015). Not having adaptation strategies is not unique to the Mt. Elgon region, similar experiences are documented elsewhere by Bryan *et al.* (2009) and Deressa *et al.* (2010). This illustrates a state of helplessness by some households especially to natural shocks.

CONCLUSION AND RECOMMENDATIONS

Farmers in the Mt. Elgon region are aware of the effects of climate change as reflected in the changes in rainfall patterns in the area. The changes in rainfall patterns noticed in the past ten years have shortened the growing season and caused uncertainty on the start and end of the growing seasons, hence disrupting the cropping calendar. The farmers' perceptions of the distribution of rains corroborates with the meteorological data of the region implying that farmers knowledge and experiences can be relied on to make decisions for intervention. The trend towards receiving more than normal rains in a shorter time than before has triggered several shocks including unprecedented dry spells within and between seasons, floods and landslides. Whereas these shocks are a recent phenomenon, the adaptation strategies such as crop intensification, soil and water management practices and diversification of income are not new, only that some of them have become more relevant now than ever before. Effects of rainfall induced shocks are apparent and the risk remains high as households undertake different interventions individually as opposed to the collective nature of interventions needed at the landscape level. Rainfall is not specific to farms and therefore its effects occur on a larger scale than the farm. Preferential and individual adaptation strategies are unlikely to be very useful even to those who undertake them. Therefore, agricultural extension practitioners need to promote interventions such as soil fertility management, controlling soil erosion, rainwater harvesting and storage for irrigation at landscape level to enhance resilience of the farming system. Promoting such interventions at landscape level invariably takes care of the individual farms. The responsibility for planning (taking into account farmers' knowledge and experiences) and executing the necessary adaptation strategies is beyond the individual farmers or farms, though the individuals will have to cooperate to undertake relevant collective actions.

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