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Household vulnerability and adaptive capacity on impacts of climate change and adaptability solution in Soroti District, Uganda

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Abstract. *Ogallo EA, Wambua BN, Mukhovi MS. 2022. Household vulnerability and adaptive capacity on impacts of climate change and adaptability solution in Soroti District, Uganda. Intl J Trop Drylands 6: 63-76.* This study aimed to assess the vulnerabilities, impacts, and adaptation strategies of households in the Soroti District, Uganda. The data from household surveys, interviews with key informants, and focused group discussions were used to obtain data on climate change and variability impacts, adaptation strategies, and vulnerability. The rainfall and temperature data from Soroti meteorological station was also used to determine climate variability and change. The Microsoft Excel 2007 and Statistical Package for Social Science (SPSS) 16 program entered all the quantitative data. The results were then represented in tables, graphs, and charts. The temperature and rainfall analysis show that the area's climate has recently changed. These scenarios were confirmed by people's perception, along with increased drought, floods, and incidences of diseases and pests. That could have serious implications for agriculture, the major source of livelihood within the district. For instance, the delay of the 2013 March-April-May (MAM) rainfall onset and extended dry spell between the seasons led to subsequent poor harvests and serious crop failure. Other major impacts of climate change and variability on livelihoods include low fish catches, decreased water availability, lack of animal feeds, and decline in soil fertility. Although the entire district is vulnerable to the impact of climate change and variability, vulnerability is heightened for women, children, the poor, and the less educated. However, the residents have adopted certain coping and adaptation strategies to deal with the climate change impacts. The current coping strategies include selling household assets, wage labor, petty trading, and reducing consumption. Adaptation strategies include shifting planting dates, off-farm jobs, planting different crops, diversifying crops, and diversifying from farm to non–farm activities. However, these strategies are insufficient due to overarching stressors such as over-dependence on rainfed agriculture, poverty, and lack of information and technology. Moreover, there is an urgent need to alleviate poverty and unemployment within the district by creating employment opportunities for the locals and enhancing the micro-financing efficiency to improve resilience and adaptation to climate change and variability. There is also a need for robust contingency planning and the relevant institutions' involvement in early warning. Local knowledge integration in climate policies also could enhance resilience and improve adaptation.

Keywords: Adaptation, Soroti District, Uganda, vulnerability

INTRODUCTION

Climate change and variability have become local phenomenon just as it is global. However, its magnitude is now being felt at almost all scales and in all regions felt and at almost all scales, with extreme events such as excessive rainfall, heat waves, drought, and dry spells affecting much of rural in the world, include Africa (Adger 2000; Dube and Phiri 2013; Loo et al. 2015; Bakari et al. 2018; Kong'ani et al. 2018; Wambui et al. 2018; Kuria et al. 2019). IPCC (2001a) signifies that scientific evidence of human-induced global warming is worse than previously estimated and unequivocal. The report states that in the last century, Africa warmed by 0.7°C and projected more for the 21st century ranging from 0.2°C (low scenario) to over 0.5°C (high scenario) per decade. Therefore, urgent action must be taken to respond to these ongoing changes. Warming is projected in all regions throughout the continent, although there is variability in the speed of change and magnitude. The anthropogenic emissions of gases (e.g., methane and carbon dioxide) increasing into the atmosphere, and a resultant enhanced greenhouse effect, are the major driving force of the accelerated global warming trend that has been observed which taken place over the last century (IPCC 2001a, 2007; Adger 2000).

Uganda's largest economy is agriculture, providing employment to 66 % of the working population and contributing up to 42% of the Gross Domestic Product (GDP) (UBOS 2011). However, the productivity and competitiveness of this sector are increasingly constrained by the temporal and spatial variability of climate (Ekere 2012). Uganda is highly susceptible to climate variability and change. The economy, as well as the well-being of its people, is dependent on rain-fed agriculture; therefore, climate change may mean increased food insecurity, soil erosion, land degradation, over-flooding leading to an outbreak of diseases like malaria, and damage to infrastructure and settlements (Twinomugisha 2005; Boon and Ahenkan 2012; Onyekuru et al. 2014). Communities located in remote areas and limited opportunity to influence the policies that affect their lives and have limited access to social services are, therefore, likely to be more vulnerable (Orindi and Eriksen 2005; Suryavanshiet al. 2012; Tambo and Abdoulaye 2013). In addition, Uganda has been experiencing an intensity of extreme weather events and an increase in the frequency with serious socio-economic consequences. Uganda experienced seven drought episodes in the 1991–2000 decade alone. Extreme droughts negatively affected hydropower production, agriculture, water resources, and the overall economy (Wasige 2009). The 1997/98 El Nino is recorded to have inflicted heavy losses. For instance, crops were destroyed, swept bridges, and water-borne diseases such as cholera and other flood-related diseases were experienced. As of December 1998, it is estimated that floods and landslides killed 100 people, and 150,000 were displaced from their homes (Wasige 2009). The higher-than-normal rains between July and October 2007 caused flooding in eastern Uganda, where Amuria, Katakwi, and Soroti districts were the most affected. Water inundated many areas, leading to heavy loss of first-season crops, which would be harvested in July/August (UNEP 2009). In February 2010, Eastern Uganda experienced water-logging, landslides, and flooding due to heavy rains. A report by the International Committee of the Red Cross (ICRC) indicated that the floods and landslides resulted in displaced people, destruction of property, and deaths. The roads were inaccessible, and food crops were destroyed. The most affected districts include Soroti, Amuria, Pallisa, Mbale, Moroto, Bukwo, Katakwi, and Budaka (ICRC 2010).

Soroti District is located in the Teso sub-region of eastern Uganda, which is considered prone to climate hazards, like the recent ones being 2007 floods and drought that hit the same area in 2009. Because of these serial shocks, the sub-region continues to be one of the least developed areas in the country (Nanduddu 2007). This study's findings will guide policy-makers and the local community to build resilience and make the social-ecological system more sustainable and adaptive to cope with climate variability's adverse influences. Finally, the study's findings add to the existing literature on climate variability impacts, adaptation, and vulnerability.

The aims of this study are (i) To examine the local's perception, mean surface temperature, and rainfall trend in the district. (ii) To assess the impacts of climate variability on livelihoods. (iii) To assess the most vulnerable groups within the district (iv) To examine the adaptation strategies of the locals to changes in climate.

MATERIALS AND METHODS

Study location and size

The study was conducted in Soroti District, located in Eastern Uganda (Figure 1). It bordered Kumi and Pallisa districts, Lake Kyoga in the South, Kaberamaido in the west, and Katakwi in the Northeast. The district covers a total land area of 2,662.5 $km^{2,}$ of which 406 km^2 is water, and 2,256.5 km^2 is land. The district lies at 1°34'60" N and 33°34'60" E, 1,097 meters above sea level. Soroti District is administratively divided into three (3) rural counties of Serere, Soroti, and Kasilo, and 1 Municipality, Soroti Municipality. In addition, there are 10 Sub-counties, 41 rural parishes, and 511 Local Council 1 units. The Local Councils (LC) make up the political structures, i.e., LC V at the district level and LC 1 at the village level.

Study design

A case study design was used since the emphasis of this study was to undertake an intensive examination of the impacts of climate change and variability on adaptive strategies, livelihoods, and vulnerability within a specific location. The case study design is important in gathering data through observing people's actions and situations and exploring the individuals' preferences, behaviors, and attitudes. Furthermore, in the case of study research, which a survey can not achieve, the exploratory questions, 'what' and' how,' are useful in harnessing detailed and valuable insights and understanding of the topic (Bryman 2008). Therefore, the case study strategy was both quantitative and qualitative.

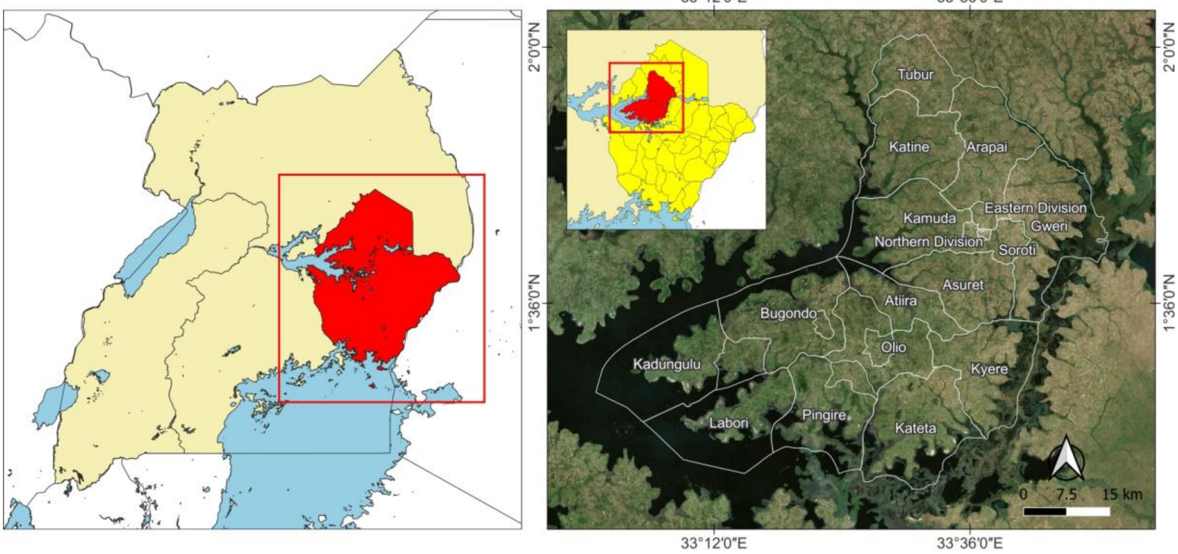

Figure 1. Map of the study area in Soroti District, Uganda

Sample size and sampling procedure

The study adopted the Cochran equation to determine the sample size. However, for large populations, Godden (2004) developed Equation 1 to yield a representative sample for proportions.

The formula is as follows:

$$n_0 = \frac{z^2 p(1-p)}{e^2}$$

Where

n = Sample size

Z = z Value (1.96 for 95% confidence level)

P = Estimated proportion of population (assumed to be 40% or 0.4) e = Margin of error (assumed to be 0.07)

Therefore,

$$n = \frac{1.96 * 1.96 * 0.4(1-0.4)}{0.0049}$$

n = 180

The multi-stage random sampling procedure was adopted to select the participating villages and households for the interviews. The 10 Sub -counties within the district were grouped in terms of high, medium, and low agricultural productivity. From each group, one sub-county was randomly selected, making up three Sub-counties. Next, two parishes were randomly selected at the sub-county level, making up 6 parishes. Then, from the 6 parishes, 9 villages were randomly selected. At the village level, systematic random sampling was used to select 20 households in each village, and lists of all households were obtained from local councils (village elders). Overall, 180 households were selected for the interview.

Data sources

Primary data

Household survey. A formal survey was conducted using a standard questionnaire. The questionnaire, which was administered to the household heads, was designed to capture information on family characteristics (family size, age, sex, educational and marital status, major source of income) and other parameters such as local perception of climate change, their coping methods to changing/ unreliable onset of rains; seasonal distribution, rainfall quantity, and intensity. A total of 180 respondents were sampled by interview.

Focused Group Discussion (FGD). Discussions were conducted with local people to get information about the past and present climate conditions, adaptation strategies, and their impacts. A total of three focused group discussions were conducted in Soroti, Katine, and Gweri sub-counties, respectively. Each focused group consisted of five youths, five men, and five women. The timeline and historical profile/ recall methods were used during the discussion to identify extreme climate events and their variability over time, frequency and intensity. In addition, FGD was used to validate and triangulate the responses from the household survey.

Key informants interview. Additional information was gathered from government staff, i.e., District Environment Officer and the District Agricultural Officer. This information was used to cross-check the views of respondents. The interview focused on climate patterns, vulnerable groups, climate variability, change impacts, and possible adaptation measures.

Field observation. Field observations were carried out several times. During the field visit, observations were made on the impacts of climate variability and change on livelihood sources. In addition, observations were carried out in the respondents' homes, farms, and the surrounding environments, and photographs were taken. Finally, the information gathered from the other sources was triangulated by observations.

Secondary data

Climatic data. Rainfall and temperature data from Soroti meteorological station were used to analyze climate change trends and variability. Rainfall data were available from 1961 to 2011, while temperature data were available from 1971 to 2007.

Socio-economic and other data. Socio-economic and other secondary data was obtained from relevant publications like books, journals, internet papers, and research publications. In addition, a literature review was done by concerned agencies such as National Agricultural Research Organization (Uganda) and the IGAD Climate Prediction and Application Center (Kenya) and libraries.

Data analysis

Microsoft-Excel 2007 and the Statistical Package for Social Science (SPSS) 16 Program processed all the quantitative data. Then the results were represented in graphs, charts, and tables. The temperature and rainfall data from Soroti meteorological station trend analysis was done using the Ms-Excel 2007. Results were presented in the form of temperature and rainfall curves and graphs. The third assessment report provided by the IPCC was used to analyze the conceptual framework. The report indicates that vulnerability is a function of the character, rate of climate variation, and magnitude to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2001a,b).

V = f (exposure, sensitivity, and adaptive capacity)

Major climatic hazards of the study area were identified based on exposure of people's livelihood assets like human, physical, biological, social, and financial capital to climate change and variability from the key informants and focused group discussions. Next, they were ranked based on their exposure and sensitivity to five capitals and the households' adaptive capacity to climatic shocks. Next, the vulnerability was assessed as a function of exposure, sensitivity, and adaptive capacity. Finally, Pearson's Chi-square analysis was used in testing the hypotheses.

The equation is specified as follows:

$$x^2 = \sum \frac{(o-e)^2}{e}$$

Where: x^2 = Chi-square statistic, o = Observed values, e = Expected values

RESULTS AND DISCUSSION

Socio-economic profile of sampled households

The socio-economic profile of the community refers to the attributes of sex, levels of education, employment status, income, age, household sizes, and main source of livelihood. These factors play an important role in determining the attitude and vulnerability of the respondents toward adaptation to climate change and variability

Sex and age of the household head

Gender and age are important factors in determining the choice of adaptation strategies and vulnerability since climate change and variability affect men and women of various ages differently, experienced by their distinguished roles and responsibilities at the household and community levels (Aguilar 2009). This study found that 78% of the household heads are male while 22% are female. Regarding age, 33% of the respondents are between 15-35 years, 35% are between 36-55 years, 22% are between 55-64 years, and 10% are between 64 years and above (Figure 2). The results suggest that most household heads in the district are men. That means that men are mostly responsible for making most decisions regarding the welfare of their households and ways of coping and/or adapting to climate change and variability.

A study conducted by Asfaw and Admassie (2004) in Ethiopia indicated that male-headed households have a higher probability of getting information about new farming technologies and undertaking more risky ventures than female-headed households. Also, Tenge and Hella (2004) point out in their study that female-headed households are less likely to adopt soil and water conservation measures since women may have limited access to information, land, and other resources because of traditional social barriers. However, given access to appropriate technology and information, most households in this study likely adopt appropriate coping and adaptation measures, thereby reducing their vulnerability to the impacts of climate variability.

The age of the respondents may also influence the vulnerability and choice of adaptation measures. Croppenstedt et al. (2003) argue that age may affect the farmer's choice of adaptation in two ways. On the one side, it may negatively influence the decision to adopt new technologies simply because older farmers are less likely to be flexible and more risk-averse than younger farmers. On the other side, age may positively influence the decision to adopt because older farmers than younger farmers have more experience in farming and are better able to assess the characteristics of new technology.

The study shows the proportion of the elderly population compared to the younger population within the district is smaller (10%). That means the district's vulnerability in terms of age is lower since, unlike the elderly, the younger population is more likely to cope with the effects of climatic extremes.

Education level of household head

Education plays an important role in an individual's personality development and also has an important role in nation-building, as there is a strong relationship between education and economic development. However, the results show that 13% of the respondents are illiterate, 65% have a primary school education, 15% have secondary education, 3% have higher education (A levels), and only 4% have acquired tertiary education (Figure 3). The probable cause of this low education status is poor economic conditions; hence people tend to abandon education to satisfy their needs. The secondary schools are also very far away from the villages, and students must cover long distances to reach them.

People with formal education, according to Nabikolo et al. (2012), are better able to respond to climatic shocks, thereby reducing their vulnerability. Maddison (2007) also emphasizes that educated and experienced farmers must have more information and knowledge about climate variability and change and adaptation measures necessary to respond to climate challenges. In addition, Norris and Batie (1987) also assert that a higher education level farmer can access information on improved technologies for higher productivity.

The low education levels within the local district could enhance their vulnerability to climate change and variability impacts, limiting their knowledge of high technology adaptation measures and climate variability.

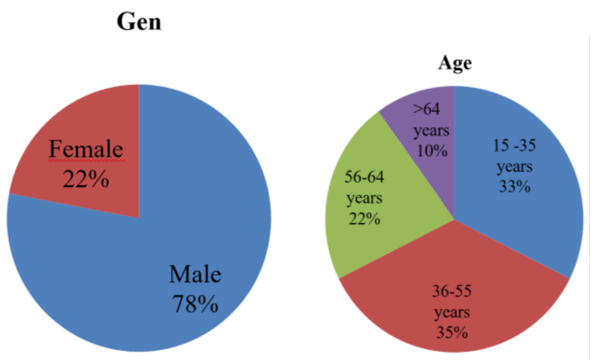

Figure 2. Sex and age of the household head.

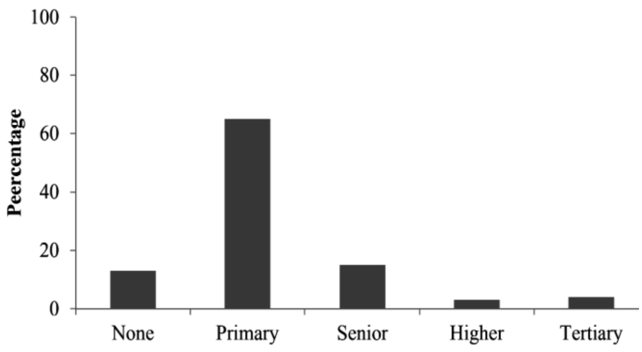

Figure 3. Education level of the household head.

Employment status and income levels

Employment and income are other important factors influencing the decision to adapt to climate change and variability. Table 1 indicates that most respondents (77.4%) are employed (i.e., full-time, part-time, or self-employed), which shows a significant number of unemployed respondents (19.3%). Figure 4 indicates that a majority (33.3%) of the respondents earn below 100,000 UG shillings (3,400 Ksh.). In contrast, the least number (3.3%) earn above 500,000 UG shillings (16,500 Ksh), with a significant number not earning any income (38.3%).

Income earnings

The low employment and income levels are proven to be living in the district. Even those engaged in some form of employment have low-income levels (Figure 4), indicating high vulnerability levels in the entire district. Anley et al. (2007) argue that improving education, income, and employment levels are important in stimulating local participation in various adaptation measures and natural resource management initiatives and reducing vulnerability to climate change. Those with better income are considered less vulnerable to climate variability and change impacts because they can use their resources to cope with climatic extremes.

Household size

Figure 5 indicates that most households have an average of 6-10 members. That is slightly above the national average household size of 5 persons per household (UBOS 2009).

Table 1. Showing the employment status of the household heads

Employment status	Frequency	Percentage
Full-time work	18	10.5
Part-time work	55	30.4
Self-employed	66	36.5
Homemaker	1	0.6
Retired	3	1.7
Student	2	1.1
Unemployed	35	19.3
Total	180	100.0

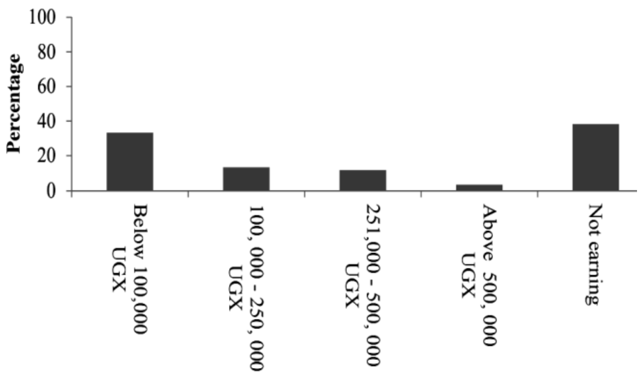

Figure 4. Income levels

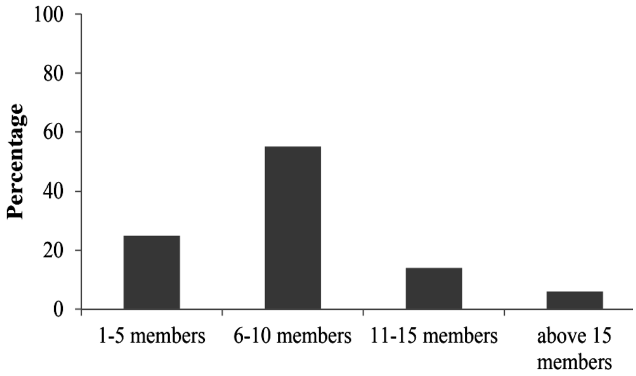

Figure 5. Size of the households

Given the low levels of education (Figure 3) and low-income status (Figure 4), due to consumer pressure imposed by large families, vulnerability to climate change and variability in the district is likely to be heightened. However, Yirga (2007) observes that large families may be able to divert part of the labor force to off-farm activities to earn income to ease the consumption pressure imposed. He also argues within a large family has a higher labor endowment, likely supporting it to accomplish various agricultural tasks. Croppenstedt et al. (2003), on the other hand, assert that households with a larger labor pool, because they have fewer labor shortages at peak times, are more likely to adopt agricultural technology and use it more intensively. Furthermore, given appropriate support, households within the district can utilize their large labor pool, enabling them to cope with climatic extremes in farm and non-farm activities to earn extra income.

Main house construction materials

The houses' construction materials also help in determining vulnerability to climatic extremes. For example, most of the main houses in Soroti (Table 2) have grass-thatched roofs (81.8%) and walls that are made of unbaked bricks (48.6%). The condition of the main house increases the vulnerability levels of the locals to extreme climatic shocks. Since these houses are constructed using unbaked bricks and grass, such as temporary materials, they can be easily swept away by extreme weather events such as floods.

Table 2. Main house construction materials

Construction materials		Frequency	Percentage
Type of walls	Mud & Wattle	63	34.8
	Wood panel	1	0.6
	Unbaked bricks	88	48.6
	Stones	1	0.6
	Baked bricks	27	15.5
	Total	**180**	**100.0**
Type of roof	Grass thatched	148	81.8
	Iron sheet	31	17.7
	Tiled	1	0.6
	Total	**180**	**100.0**

Access to facilities and services

Ease of access to markets, hospitals, credit, and other services could reduce vulnerability significantly. The study indicated that 100% of the respondents interviewed have no access to television, while most respondents (69.1%) have radio access. In addition, 100% of the respondents have no access to electricity, and only 27.6 % have access to credit (Table 3). Table 4 shows that most of the respondents can access certain facilities within a short time, within an hour; for instance, 38.7% can access the nearest market in less than an hour, 46.1% can access the nearest health center in less than an hour, and 59.1% can access the nearest vehicle station in less than an hour.

Access to facilities such as television and radio could increase access to information required for deciding on climate change adaptation. Various studies indicate a strong positive relationship between access to information and the adaptation behavior of farmers in developing countries (Yirga 2007). Furthermore, through extension services, access to information also increases the possibility of adapting to climate change (Nhemachena and Hassan 2007). In addition, ease of access to facilities such as markets, vehicle stations, and hospitals can help reduce vulnerability to climatic shocks.

The main source of livelihood

Most of the respondents (91%) depend on farming as their main source of livelihood (Figure 6). However, most respondents (73.9%) also practice mixed farming. The crops grown and livestock are for subsistence and commercial purposes (Tables 4 and 5).

Table 3. Access to facilities and services

Facility / Service		Frequency	Percent
Access to television	No	180	100.0
Access to Radio	Yes	124	69.1
	No	56	30.9
	Total	**180**	**100.0**
Access to Electricity	No	180	100.0
Access to Credit	Yes	50	27.6
	No	130	72.4
	Total	**180**	**100.0**

Table 4. Ease of access to various facilities

	Time taken	Frequency	Percentage
Time took to reach nearest vehicle station	Less than one hour	107	59.1
	One hour	39	21.5
	More than one hour	34	19.3
	Total	**180**	**100.0**
Time took to reach the nearest health center	Less than one hour	83	46.1
	One hour	36	20.0
	More than one hour	61	33.9
	Total	**180**	**100.0**
Time took to reach the nearest market	Less than one hour	70	38.7
	One hour	42	23.2
	More than one hour	68	38.1
	Total	**180**	**100.0**

Table 5. Type of farming practiced

Description of farming		Frequency	Percent
Type of farming	Crop farming only	41	22.8
	Livestock rearing/herding only	6	3.3
	Mixed farming (Crop & Livestock production)	133	73.9
	Total	180	100.0

Table 6. Type of agriculture practiced

Type of agriculture practiced	Rain-fed	175	97.2
	Irrigated	1	0.6
	Not farming	4	2.2
	Total	180	100.0
Reason for doing farming	Subsistence	36	20
	Commercial	0	0.0
	Both subsistence & commercial	140	77.8
	N/A	4	2.2
	Total	180	100.0

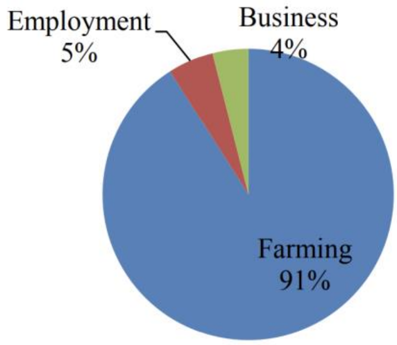

Figure 6. Sources of livelihoods. Source: Field data, 2013

Results from Figure 6 and Table 6 indicate that the main source of livelihood in the Soroti District is rain-fed agriculture. However, rain-fed agriculture is highly vulnerable to climate change and variability (Eriksen 2000; FAO 2008). Therefore, it is highly affected by unseasonal and irregular rainfall patterns, negatively affecting crop farming and livestock. The impacts can include a lack of feed for cattle and crop failure, animal diseases, and lack of water. Therefore, these impacts increase the risk of food insecurity and threaten the people's main source of livelihood. For instance, the extended dry spell in the 2013 March-April-May (MAM) season led to serious crop failure within the district.

Perception and trend of climate change and variability

Respondent's perception of climate variability and change

Local knowledge and perception about climate change are very important in enabling the locals to cope with the negative impacts of climate variability. Table 7 shows that most respondents (97.8%) had mentioned changes in climate and its variables over the past years. For example, most respondents (72.3%) described that the rainfall onset was late, while the biggest fraction (66.1%) described that rainfall amounts were less. More so, slightly less than half of the respondents reported that seasonal rainfall distribution was heavier in the second season (48.6%), whereas the highest proportion mentioned that cessation was early (64.4%). Most respondents (70.7%) also felt that the temperatures were increasing.

The results show that the respondents are aware of climate change and variability and have noticed changes in weather patterns over the last 5-30 years. The variation in temperature increase and rainfall amounts was found to significantly negatively affect farming, which is the main source of livelihood. The indication that there had been a significant change in climate over the past years resulted from three different focus group discussions. Based on their local knowledge, there was a consensus that rainfall patterns have been erratic between genders over the last three decades.

The variability in rainfall patterns makes it increasingly difficult to plan land preparation and planting times, argued one participant. The dry spells have become more frequent and severe, and the rains start late and end early, sometimes with an extended dry spell between seasons, argued another participant. He further stated that "this unpredictable rainfall pattern in 2013 led to serious crop failure in the first season."

Climate trend analysis

Rainfall analysis

The trend analysis on rainfall shows some significant changes in rainfall patterns. The average annual rainfall pattern over the past 50 years in the Soroti District (1961-2011) shows a decreasing trend in rainfall amounts. The analysis also shows that there has been a significant variation in rainfall within the district in the last 50 years (1961-2011), with a significant decline in the years 1980, 1987, 1993, 2004, and 2011 and a considerable increase in the years 1975, 1978, 1991, 1996, and 2000 (Figure 7).

The respondents' perceptions are aligned with the actual climatic data. Rainfall data shows that the potential crop growing period is shrinking, maybe because the average annual rainfall is decreasing in the Soroti, which is well collaborated by most respondents (66 .1%) reporting that the rainfall amounts are light (Table 7). The variations in the rainfall pattern are very significant for the locals because any changes in rainfall will hamper crop production because they are directly dependent upon rain-fed agricultural practices. Excessive rainfall could cause flooding and soil erosion, while a decline in rainfall could lead to crop failure.

Annual average rainfall in decades

Figure 8 shows an analysis of the annual rainfall averages for five decades, showing that the highest rainfall amounts occurred in the 1961-1970 and 1981-1990 decades. The lowest rainfall amounts were experienced in the 1971-1980 and 2001-2010 decades. There is also a notable rainfall reduction in the last decade (2001-2010).

Table 7. Perception and knowledge of climate change and variability

		Frequency	Percent
Respondents who have observed changes in weather patterns over the last 5-30 years	Yes	177	97.8
	No	3	2.2
	Total	180	100.0
Changes observed (rainfall)			
Rainfall onset	Early	18	10.2
	Normal	3	1.7
	Late	128	72.3
	Variable	28	15.8
	Total	177	100.0
Rainfall amounts	Light	117	66.1
	Normal	6	3.4
	High	9	5.1
	Variable	45	25.4
	Total	177	100.0
Rainfall seasonal distributions	Normal	7	4.0
	Heavier in the first season	32	18.1
	Heavier in the second season	86	48.6
	Drought interspersed within seasons	23	13.0
	Variable	29	16.4
	Total	177	100.0
Cessation (end of rainy season)	Early	113	64.4
	Normal	9	5.2
	Late	55	30.5
	Total	177	100.0
Temperature	Lower	15	8.6
	Moderate	24	13.2
	Higher	124	70.7
	Variable	14	7.5

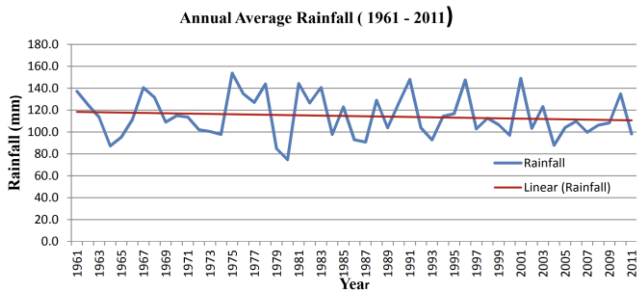

Figure 7. Annual average rainfall from Soroti meteorological station (1961 -2011). Source: Soroti Meteorological Station 2013

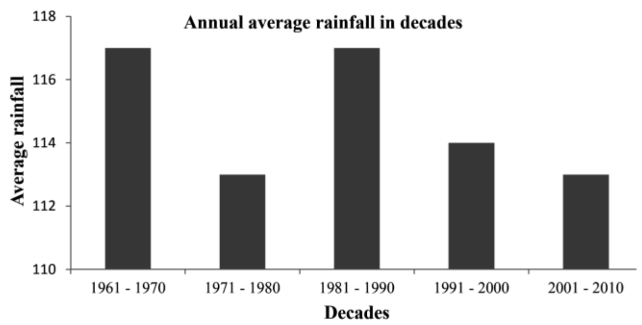

Figure 8. Annual average rainfall in decades. Source: Soroti Meteorological Station (2013)

Temperature analysis

The temperature data for Soroti obtained from meteorological data for 1971-2007 were analyzed, resulting in Figures 9 and 10 indicating some visible temperature changes for 36 years (1971-2007). Over the years, there has been a significant increase in both the maximum and minimum temperatures. This increase in temperature leads to a significant decline in available water resources and could hamper plant growth.

Average maximum temperature in decades

Figure 11 shows the increasing trend of temperatures in decades. For example, the average decade temperature calculated for 1971-1980, 1981-1990, and 1991 -2000 provide 29.8º, 29.9º, and 30.6º, respectively, with the highest increase in the last decade.

Figures 9, 10, and 11 show the temperature variability of the area. The general trend in the aggregate mean annual temperatures from 1971 to 2007 gradually increased. For example, from a low of 29.8 ºC in the 1971-1980 decade, maximum temperatures increased to 30.6ºC in the 1991-2000 decade (Figure 11), which shows an increase of 0.8ºC between the 1981 - 1990 and 1990 -2000 decades. That increase could have an enormous effect on agriculture due to evaporation and evapotranspiration rates, thereby reducing soil moisture.

A study by Ouedraogo et al. (2006) conducted in Burkina Faso found that a 1°C increase will reduce farm revenue by 19.9 US$/ha, while if precipitation increases by 1 mm/month, net revenue will increase by 2.7 US$/h using a standard Ricardian model. Those findings show that agriculture is very sensitive to precipitation in Burkina Faso. In Ethiopia, the results are not different. A study by Deressa (2006) in Ethiopia reveals that net farm revenue would fall in summer and winter if temperature increases, whereas increasing precipitation during spring will increase net farm revenue. In Ethiopia, the results are not different from Burkina Faso.

Type of climatic shock that is the main concern

Figure 12 shows that drought was stated as the most frequent climatic shock of main concern, followed by floods in the Soroti District.

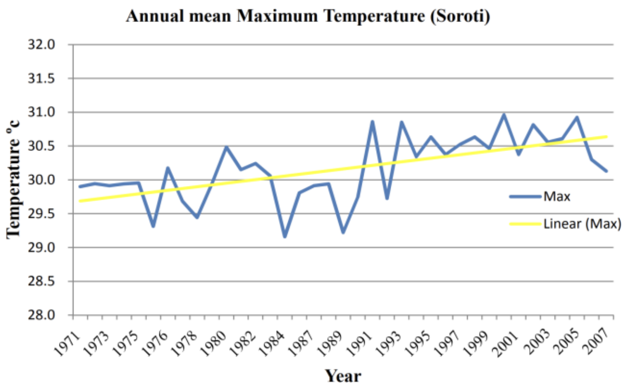

Figure 9. Annual mean maximum temperatures (1971-2007). Source: Soroti Meteorological Station (2013)

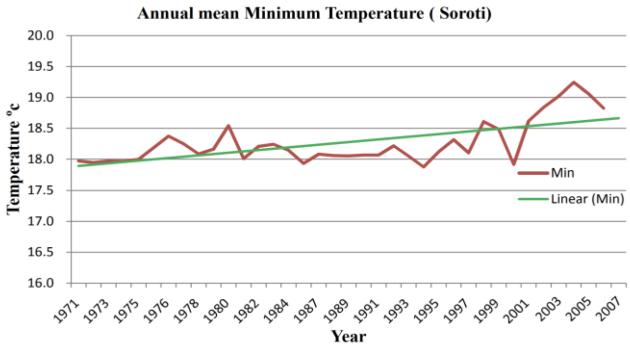

Figure 10. Annual mean minimum temperature (1971-2007). Source: Soroti Meteorological Station (2013)

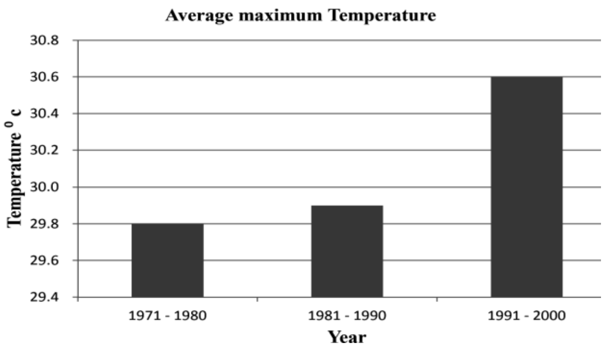

Figure 11. Average maximum temperatures in decades. Source: Soroti Meteorological Station (2013)

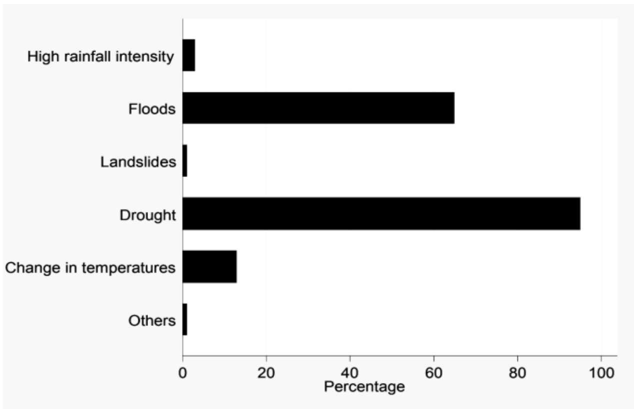

Figure 12. Shows the type of climatic shock that is of main concern to the residents

Hypothesis 1: There is no significant variation in climatic extremes such as drought and floods across different villages in the Soroti District

Drought, land degradation, ecosystem degradation, and flood hotspots within Soroti District were identified by testing the relationship between the village of residence and the type of climatic shock experienced at a 95% confidence level, as shown in Table 8: (i) A significant relationship was established between the type of climatic shock experienced and the village name of residence ($p < 0.05$). (ii) High rainfall intensity was witnessed in Aputon compared to other villages (10.5%). On the other hand, floods were witnessed most in Asinge village compared to the others (66.7%). (iii) Drought was common in Omirio compared to other villages (69%). (iv) Temperature changes were experienced most in Aputon compared with other villages (26.3%). On the other hand, landslides had not been experienced by most of the locals in the district.

Impact of climate change on livelihoods

The evidence gathered during the respondent's interview suggests that climate change and variability have frequently been imposing various challenges on their livelihoods and consequently affecting the society's socio-economic activity of the local people. For example, Table 7 shows that the main impact on crop farming in Soroti District of climate change and variability is crop damage (56.1%). In comparison, the main impact on livestock farming is the lack of animal feed (28.9%).

Regarding fishing, the main impact of climate change and variability was low fish catches reported by the biggest fraction of households (41.1%). Most respondents stated the main impact of climate change on water resources was decreased water availability (73.9%). The biggest fraction of respondents (38.9%) reported the main impact of climate change on land resources was a decline in soil fertility (Tables 8 and 9).

Agriculture in the Soroti District is purely rain-fed and is the main livelihood source for 91% of the respondents (Figure 6). The irregular and unseasonal rainfall patterns have negatively affected crop and livestock farming, threatening people's food security and well-being. The main impacts in the Soroti District of climate variability and change have been crop damage and, in some instances, total crop failure due to delays in the onset of rains and extended dry spells. As the focus group discussions noted, the extended dry spells in the 2013 March-April-May (MAM) season significantly negatively impacted the harvest and the general household food security. It led to subsequent poor harvests and serious crop damage.

The study found that concerning livestock production, drought and delay in the onset of rain led to poor grass regeneration and forage deficit, heat stress on livestock, and water shortage, consequently increasing livestock mortality. The information gathered from the District Agricultural officer indicated that the animals were more susceptible to diseases, such as sheep and goat pox, *coccidiosis*, anthrax, and *Salmonelliosis*. The impact of climate change on the distribution of several infectious disease vectors and the seasonal distribution of some allergenic pollen species was highlighted by the IPCC's fourth assessment report. According to this report, diseases previously limited to low latitudes have spread to higher latitudes. Insect-borne diseases such as *anaplasmosis* and *trypanosomosis* are now found in many parts of the world where their vectors have never been found in the past. In association with land use change, the climate has been associated with global increases in mortality and morbidity from emergent parasitic diseases (IPCC 2007).

Table 9. Impacts of climate change and variability on agriculture

Livelihood source	Impact	Frequency	Percent
Crop farming	Crop failure	72	40
	Crop damage	101	56.1
	Pest infestation	4	2.2
	Others	1	0.6
	N/A	2	1.1
	Total	**180**	**100.0**
Livestock farming	Lack of feeds	52	28.9
	Water shortage	34	18.9
	Low milk production	4	2.2
	Small grazing areas	24	13.3
	Disease prevalence	22	12.2
	Death of livestock	10	5.6
	Others (n/a)	34	18.9
	Total	**180**	**100.0**

Table 8. Percentage distribution of major climatic shock by the village of residence

Village name		Type of climatic shock that is your main concern						Total
		High rainfall intensity	**Floods**	**Landslide**	**Drought**	**Change in temperatures**	**Others**	
Aputon	Count	2	3	0	9	5	0	19
	% Within village	10.5	15.8	0.0	47.4	26.3	0.0	100.0
Ojwiny	Count	0	4	0	4	1	1	10
	% Within village	0.0	40.0	0.0	40.0	10.0	10.0	100.0
Agora	Count	0	12	0	18	1	0	31
	% Within village	0.0	38.7	0.0	58.1	3.2	0.0	100.0
Amen A	Count	1	9	0	15	5	0	30
	% Within village	3.3	30.0	0.0	50.0	16.7	0.0	100.0
Omirio	Count	0	8	1	20	0	0	29
	% Within village	0.0	27.6	3.4	69.0	0.0	0.0	100.0
Otidonga	Count	0	6	0	8	0	0	14
	% Within village	0.0	42.9	0.0	57.1	0.0	0.0	100.0
Asinge	Count	0	10	0	5	0	0	15
	% Within village	0.0	66.7	0.0	33.3	0.0	0.0	100.0
Olelai	Count	0	6	0	4	0	0	10
	% Within village	0.0	60.0	0.0	40.0	0.0	0.0	100.0
Gweri	Count	0	7	0	12	1	0	20
	% Within village	0.0	35.0	0.0	60.0	5.0	0.0	100.0
Total	Count	3	65	1	95	13	1	178
	% Within village	1.7	36.5	0.6	53.4	7.3	0.6	100.0

Note: Test of hypothesis/Significance: Chi-square=64.673. Degrees of freedom=40 p-value=0.008

Heavy rainfall was found to negatively and positively impact livestock production. The negative ones include livestock deaths from bloating and over-eating weak animals that survived the drought. In contrast, the positive impacts include increased water availability and enhanced grass regeneration, as noted in the focused group discussions.

Natural ecosystems and biodiversities are also affected by the changing climate. For example, respondents from the focused group discussion cited that they have experienced the loss of some native plants and species within the surrounding forests, grassland, and wetlands. In addition, 41.1% of the respondents from the household survey also indicated that they are experiencing low fish catches due to reduced fish quantities.

Even though there are sufficient water sources, as observed from the numerous wells and boreholes within the district, the local people said they are facing more dry spell periods resulting in decreased water in these sources, which may affect agriculture and food security. The other impact of climate variability and change include soil erosion and the decline in soil fertility from heavy rainfall, especially in flood-prone Gweri Sub-county.

Vulnerability

Vulnerable groups

The highest proportion of the respondents (39%) felt that women are most vulnerable, next to the poor (31%) and the less educated (14%) (Figure 13).

The poor

The District Environment Officer (DEO) pointed out that because of their dependence on a natural resource such as land as their source of livelihood, the poor are more vulnerable to climatic shocks; hence their sources of livelihood are negatively impacted when there is drought or floods, making them more vulnerable. In addition, the poor depend on daily wage labor, have fewer reserves to absorb climatic shocks, and have lower incomes. Respondents from the focused group added that due to the general perception that they cannot afford to pay it back, the poor do not have access to loans and credit.

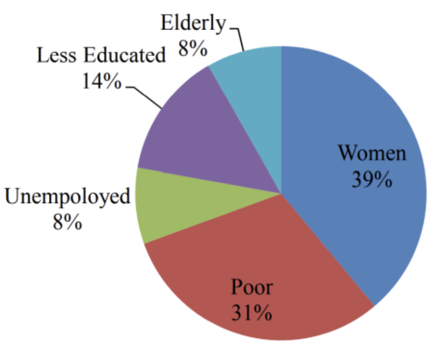

Figure 13. Vulnerable groups. Source: Field Data (2013)

Figure 4 indicates that the majority of those working earn below 100 thousand Ugandan shillings per month, which are supposed to be low-income levels, thus increasing their vulnerability to climatic extremes. Furthermore, the condition of the study areas shows that they are mostly made of unbaked bricks and wood, which are traditional houses. That also displays the vulnerability of the whole community during natural disasters, especially in Gweri Sub-county, which is considered flood-prone. Cross-referencing employment status, education levels, and house construction structure show the district's poverty level. A study conducted in Bangladesh by Brouwer et al. (2007) shows that households with less access to productive resources and lower income are more vulnerable to climatic risk exposure. They also show that with the presence of income and asset disparity and under the climatic shock, individual households become more vulnerable at the community or collective level since the collective level is least capable of facing a common shock like a flood.

Women

Results from the household survey, the key informant interviews, and focused group discussions indicate that women are more vulnerable to climate change and variability than men. Women's vulnerability was explained by their confinement at home caring for children and family members, poor nutritional status, a lack of access to the property, and lack of empowerment. According to the district, Environment officer, "Women's Women's closeness to family members and confinement at home and closeness to family members makes them most suffering because men can move to look for an alternative source of livelihood to nearby towns."

Aguilar (2009) argues that women tend to have more limited access to the assets (financial, human, social, physical, and natural capital) that would enhance their capacity to adapt to climate change, such as land, decision-making bodies, agricultural inputs, technology, credit, and extension and training services. Thus any climate adaptation strategy should include ways to reduce climate-related risks and actions to build up women's assets, such as improving their access to skills, knowledge, and education and strengthening their ability to prepare for and manage risks.

Less educated

The education status of the household heads has been explored through the survey (Figure 3). The study shows that many interviewed people have completed primary education, but many respondents have been presented as illiterate. Higher, secondary, and Tertiary education has been achieved by a very small percentage of the respondents. The overall education status of the household heads shows adult literacy level is lower in the community as a whole. Yet, adults' higher education levels increase the possibilities of creating new ideas and open-mindedness. Adults in this community are less likely to adopt alternative livelihoods if it becomes necessary due to climate variability and change.

Vulnerability by the source of livelihood

Results from Figure 6 indicate that most respondents (91%) indicated that farming is their main source of livelihood. Furthermore, most respondents (97.2%) also indicated that they practiced rain-fed agriculture (Table 6). That means they directly depend on rainfall in their farming practices; even the district's agriculture sector is dominated by small-scale farmers, who depend on rain for crop production. However, most studies agree that rain-fed agriculture is highly vulnerable to climate change and variability (Eriksen 2000; FAO 2008). Therefore, any climate change mostly manifested as an increase in low rainfall amounts, frequency, and severity of extreme weather events such as floods and drought can significantly reduce household food security and agricultural production.

Hypothesis 2: Vulnerability to climatic extremes varies significantly with the education levels of the household heads

The relationship could not be established significantly between the type of climate-related risk experienced and the education level of the household head ($p > 0.05$). That implies that vulnerability does not vary with the education level of household heads.

Coping and adaptation strategies

The results show that the highest proportion (33.3%) of households applied wage labor as a major coping mechanism to the climatic risk once they had experienced drought. The biggest fraction of households (23.9%) also applied grain storage as a major coping mechanism to the climate risk once they had experienced floods. The largest proportion of households (21.7%) applied wage labor as a major coping mechanism to the climatic risk once they had experienced a poor harvest. Finally, the biggest fraction of households (19.4%) also applied grain storage as a major coping mechanism to the climatic risk once they had experienced food shortages (Tables 12 and 13).

When faced with the above unpredictable climate-related risks, the Soroti District residents adopt different coping mechanisms. Much of this response is reactive because it is triggered by current or past events such as drought and floods. Still, it is also anticipatory as it is based on some assessment of conditions in the future, for example, rainfall occurrence. Therefore, some coping strategies are adopted before the occurrence of the climatic risk, while others are activated as the risks develop.

This study shows that the most common coping mechanisms to reduce vulnerability to climatic shocks employed by the locals are wage labor (farm or non-farm activities that the locals engage in to earn income) and grain storage (Tables 10 and 11). However, these coping strategies are not sustainable because employment opportunities are not always available to the locals. When there is a poor harvest, the people lack enough grain to store for future use.

Adaptation technologies

Results show that the main adaptation strategies to climate shocks are shifting planting dates (95.6%), crop diversification (86.7%), and diversifying from farming to non-farming activities (54.5%). Moreover, it was also cited that a smaller percentage of households significantly use irrigation (3.3%) (Table 14).

Table 14 shows that to deal with various climatic risks, most households in this study preferred multiple adaptation measures. For instance, most households employed shifting planting dates, crop diversification, and diversifying from farming to non-farming activities to deal with climatic extremes.

For the local people, to an extent, crop diversification guarantees good harvests; however, there are many years in which farmers report a total crop failure. Therefore, policies on adaptation that target such farmers to ensure that feasible farmer adaptations are promoted and supported should be worked out consultatively with farmers. Furthermore, the cultivation of both short and long-cycle crop varieties enables households to take advantage of the maturing times of crops to strengthen their resilience to increase chances of having good harvests during the drier and wetter seasons to impacts associated with unpredictable and variable rainfalls and drier conditions. For instance, in Gweri Sub-county, the locals have ventured into rice farming in nearby wetlands.

Consistent with a study conducted in Tanzania, diversification has been identified as a potential farm-level adaptation to climatic variability. Paavola (2004) found out that farmers switch between crops, alter the mix of crops, and change planting dates in light of the evidence they obtain of the growing season. Another study by Ssewanyana and Kasirye (2010) found that farmers in Uganda, as a form of insurance against rainfall variability and pests attack, use mixed cropping and diversification of crops.

Table 10. Impacts of climate change on natural resources

Natural resource	Impact	Frequency	Percentage
Fishing	Low fish catches	74	41.1
	High fish catches	6	3.3
	Low fish weight	23	12.8
	Decreased fish varieties	13	7.2
	Increased fish variety	1	0.6
	Low volumes of water	15	8.3
	High volumes of water	3	1.7
	Others(N/A)	45	25
	Total	**180**	**100.0**
Water resources	Increased water availability	22	12.2
	Decreased water availability	133	73.9
	Decreased water quality	24	13.3
	Others	1	0.6
	Total	**180**	**100.0**
Land resources	Decline in soil fertility	70	38.9
	Soil erosion	22	12.2
	Land degradation	20	11.1
	Loss of vegetable cover	62	34.4
	Loss of indigenous plants	2	1.1
	Others	4	2.2
	Total	**180**	**100.0**

Table 11. Distribution of climate-related risks by the education level of household head

Climate-related risk experienced		Education level of household head					
		None	Primary	Senior	Higher	Tertiary	Total
Droughts	Count	22	97	25	2	7	153
	% within education level	88.0	85.8	83.3	100.0	87.5	85.9
Floods	Count	17	66	13	1	3	100
	% within education level	68.0	58.4	43.3	50.0	37.5	56.2
Landslides	Count	0	0	0	0	0	0
	% within education level	0.0	0.0	0.0	0.0	0.0	0.0
Hailstorms	Count	1	9	5	0	0	15
	% within education level	4.0	7.9	16.7	0.0	0.0	8.4
Disease & pest epidemics	Count	4	21	5	1	2	33
	% within education level	16.0	18.6	16.7	50.0	25.0	18.5
Lightning strikes	Count	0	0	0	0	0	0
	% within education level	0.0	0.0	0.0	0.0	0.0	0.0
Bush fire	Count	0	0	1	0	0	1
	% within education level	0.0	0.0	3.3	0.0	0.0	0.56
Decreasing water resources	Count	4	5	0	1	0	10
	% within education level	16.0	4.4	0.0	50.0	0.0	5.6
Invasive weeds	Count	0	3	1	0	0	4
	% within education level	0.0	2.7	3.3	0.0	0.0	2.2
Extinction of some indigenous species	Count	0	2	0	0	0	2
	% within education level	0.0	1.8	0.0	0.0	0.0	1.1
Lack of pasture	Count	3	10	5	0	2	20
	% within education level	12.0	8.85	16.7	0.0	25.0	11.2
Poor harvest	Count	15	79	20	1	3	118
	% within education level	60.0	69.9	66.7	50.0	37.5	66.3
Food shortage	Count	21	74	19	2	5	121
	% within education level	84.0	65.5	63.3	100.0	62.5	67.9
Increasing water volumes	Count	1	2	2	0	0	5
	% within education level	4.0	1.77	6.7	0.0	0.0	2.8
Total	Count	88	368	96	8	22	582
	% within education level	352.0	325.7	320.0	400.0	275.0	326.9

Note: Test of hypothesis/Significance: Chi-square=206.714. Degrees of freedom=204 p-value=0.396

Table 12. Coping mechanisms applied for the major climatic risks

Climate-related risk	Coping mechanism	Freq.	%
Drought	Sell household assets	21	11.7
	Reduced socialization for saving	2	1.1
	Wage labor	60	33.3
	Making local drink	10	5.6
	Petty trading	35	19.5
	Grain storage	40	22.2
	Credit from merchants or money lenders	2	1.1
	Buy food on credit	7	3.9
	Consumption of wild fruits/ game meat	3	1.7
	Total	180	100.0
Floods	Sell household assets	20	11.1
	Government assistance	2	1.1
	Wage labor	33	18.3
	Petty trading	34	18.9
	Migration in search of employment	2	1.1
	Grain storage	43	23.9
	Buy food on credit	15	8.3
	Conservation Agriculture	31	17.2
	Total	180	100.0

Table 13. Coping mechanisms during poor harvest and food shortage

	Coping mechanism	Freq.	%
Poor harvest	Sell household assets	10	5.6
	Wage labor	39	21.7
	Making local drink	12	6.7
	Petty trading	21	11.7
	Reduction of consumption level	30	16.7
	Grain storage	30	16.7
	Buy food on credit	31	17.2
	Borrowing food	4	2.2
	Others (food aid)	3	1.7
	Total	180	100.0
Food shortage	Sell household assets	10	5.6
	Wage labor	30	16.7
	Petty trading	23	12.8
	Giving community service (food for work)	5	2.8
	Reduction of consumption level	34	18.9
	Migration in search of employment	13	7.2
	Grain storage	35	19.4
	Borrowing food	24	13.3
	Consumption of wild fruits/game	3	1.7
	Others (food aid)	3	1.7
	Total	180	100.0
	Buy food on credit	31	17.2
	Borrowing food	4	2.2
	Others (food aid)	3	1.7
	Total	180	100.0

Table 14. Adaptation technologies used to deal with climatic shocks

Adaptation strategies to climatic extremes	Yes		No	
	Freq.	%	Freq.	%
Diversify crops	156	86.7	24	13.3
Shift planting dates	172	95.6	8	4.4
Irrigation	6	3.3	174	96.7
Change from crop to livestock farming	2	1.1	178	98.1
Migrate to an urban area	40	22.2	140	77.8
Change the quantity of land under cultivation	21	11.7	159	88.3
Implement soil conservation techniques	57	31.7	123	68.3
Diversify of farming to non-farming	98	54.4	82	45.6

The risk of complete harvest failure due to a climatic event, such as intense rainfall, drought, or high-temperature spells, is reduced by having different crops in the same field or various plots with differing crops since not all crops and fields are affected by the same way by such climate events (Ssewanyana and Kasirye 2010). However, limitations associated with cultivating crops all year round are low yields due to limited time, labor, and capital. Although the migration of family members is very rare in the district, to meet household expenditure in times of food shortage, seasonal migration takes place in search of employment.

Major challenges that hinder effective adaptation

Table 15 shows, as identified in this study that the key issues that hinder effective adaptation include lack of money (33.3%), poverty (27.2%), lack of information (19.1%), and lack of technology (13.4%).

The main constraints that hinder adaptation in Soroti District are a lack of financial resources and poverty. The study found that despite numerous adaptation options that locals were willing to apply and aware of, a lack of sufficient financial resources to purchase the necessary inputs, invest in, and other associated equipment (e.g., seeds, feeds) were significant constraints to adaptation.

It is also apparent that if household members need to change their present occupation because of climate change-related risks, they possibly face great challenges due to poverty and lack of capital, limiting their ability to diversify from farm to non–farm practices. Paavola (2004) indicates that poor households often face constraints and difficulties in agricultural production related to varying climates compared to other households.

Table 15. Major constraints that hinder the ability to adapt

Constraints	Freq.	Percent
Lack of money	60	33.3
Lack of Information	35	19.1
Poverty	49	27.2
Lack of credit	3	1.9
Lack of technology (agricultural inputs)	24	13.4
Lack of Extension service	7	3.9
lack of market access or poor transport link	2	1.2
Total	**180**	**100%**

The other major constraints included a lack of technology and information. Access to technology and extension services can significantly increase the probability of adopting adaptation options. However, the respondents claim they have little access to extension services in the study area. Sometimes, the services and information obtained from the concerned institutions are inappropriate or useless.

REFERENCES

Adger WN. 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Climatic Change 47 (4): 325-352. DOI: 10.1023/A:1005627828199.

Aguilar L. 2009. Women and climate change; Vulnerabilities and adaptive capacities. In: Starke L (eds). State of The World: Into A Warming World. A Worldwatch Institute Report On Progress Towards A Sustainable Society. W.W. Norton & Company, New York.

Anley Y, Bogale A, Haile-Gabrile A. 2007. Adoption decision and use intensity of soil and water conservation measures by smallholder subsistence farmers in Dedo District, western Ethiopia. Land Degrad Dev 18: 289-302. DOI: 10.1002/ldr.775.

Asfaw A, Admassie A. 2004. The role of education on the adoption of chemical fertilizer under different socio-economic environments in Ethiopia. Agric Econ 30 (3): 215-228. DOI: 10.1111/j.1574-0862.2004.tb00190.x.

Bakari MS, Abdallah JM, Hella JP. 2018. Adaptation strategies of small-scale agriculture production to climate change impacts in Micheweni, Tanzania. Trop Drylands 3: 60-75. DOI: 10.13057/tropdrylands/t030205.

Boon E, Ahenkan A. 2012. Assessing climate change impacts onecosystem services and livelihoods in Ghana: Case study of communities around Sui Forest Reserve. J Ecosyst Ecogr S3: 001. DOI: 10.4172/2157-7625.S3-001.

Brouwer R, Akter S, Brander L, Haque E. 2007. Socio-economic vulnerability and adaptation to environmental risk: A case study of climate change and flooding in Bangladesh. Risk Anal 27: 313-326. DOI: 10.1111/j.1539-6924.2007.00884.x.

Bryman A. 2008. Social Research Methods. Oxford, New York.

Croppenstedt A, Demeke M, Meschi MM. 2003. Technology adoption in the presence of constraints: the case of fertilizer demand in Ethiopia. Rev Dev Econ 7 (1): 58-70. DOI: 10.1111/1467-9361.00175.

Deressa TT. 2006. Measuring the economic impact of climate change on Ethiopian agriculture: Ricardian approach. CEEPA Discussion Paper No. 25, Centre for Environmental Economics and Policy in Africa - CEEPA, University of Pretoria, South Africa. DOI: 10.1596/1813-9450-4342.

Dube T, Phiri K. 2013. Rural livelihoods under stress: The impact of climate change on livelihoods in South Western Zimbabwe. Am Intl J Contemp Res 3 (5): 11-25.

Ekere W. 2012. The Impact of Climate Change and Variability on Agricultural Production: Adaptation Strategies in Teso Sub-Region of Eastern Uganda. RUFORUM, Uganda.

Eriksen S. 2000. Responding to Global Change: Vulnerability and Management of Agro-Ecosystems in Kenya and Tanzania. [Thesis]. Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, UK.

FAO. 2008. Climate Change and Food Security: A Framework Document. Rome.

ICRC. 2010. International Committee of the Red Cross. Africa ICRC Annual Report International Food Policy Research Institute (2010). Discussion paper 01042.

IPCC. 2001a. Climate change 2001: Impacts, Adaptation and Vulnerability. Contribution of working group I: The scientific basis to the Third Assessment Report of the Intergovernmental Panel on Climate change, Cambridge University Press, Cambridge, UK, and New York.

IPCC. 2001b. Climate change 2001: Impacts, Adaptation and Vulnerability. Contribution of working group II: Impacts, Adaptation and Vulnerability to the Third Assessment Report of the

Intergovernmental Panel on Climate change, Cambridge University Press, Cambridge, UK, and New York.
IPCC. 2007. Climate Change Impacts, Adaptation and Vulnerability. The Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report.
Kong'ani LNS, Mutune JM, Thenya T. 2018. Analysis of climate change knowledge and its implications on livelihood options around Naituyupaki Location, Maasai Mau Forest, Narok County, Kenya. Asian J For 2: 62-66. DOI: 10.13057/asianjfor/r020204.
Kuria EK, Machuka J, Runo S. 2019. Maize bioengineering with c-repeat binding factor 1 (CBF1) as a technique for drought tolerance. Trop Drylands 3: 1-10. DOI: 10.13057/tropdrylands/t030101.
Loo YY, Billa L, Singh A. 2015. Effect of climate change on seasonal monsoon in Asia and its impact on the variability of monsoon rainfall in Southeast Asia. Geosci Front 6 (6): 817-823. DOI: 10.1016/j.gsf.2014.02.009.
Maddison D. 2007. The Perception and Adaptation to Climate Change in Africa. World Bank Policy Research Working Paper 4308, Sustainable Rural and Urban Development Team. DOI: 10.1596/1813-9450-4308.
Nabikolo D, Bashasha B, Mangeni MN, Majaliwa JGM. 2012. Determinants of climate change adaptation among male and female headed farm households in eastern Uganda. Afr Crop Sci J 20 (2): 203-212.
Nanduddu S. 2007. Lived Experiences: Adaptation to Climate Change in Gogongo Sub County, Palisa District, Uganda.
Nhemachena C, Hassan R. 2007. Micro-level analysis of farmers' adaptation to climate change in Southern Africa. RePEc, Africa.
Norris E, Batie S. 1987. Virginia farmers' soil conservation decisions: an application of Tobit analysis. Southern J Agric Econ 19 (1): 89-97. DOI: 10.1017/S0081305200017404.
Onyekuru AN, Marchant R. 2014. Climate change impact and adaptation pathways for forest-dependent livelihood systems in Nigeria. Afr J Agric Res 9 (24): 1819-1832.
Orindi VA, Eriksen S. 2005. Mainstreaming adaptation to climate change in the development process in Uganda. Africa Portal, Africa.
Ouedraogo M, Some L, Dembele Y. 2006. Economic impact assessment of climate change on agriculture in Burkina Faso: a Ricardian approach ', CEEPA Discussion Paper # 24, Centre for Environmental Economics and Policy in Africa -CEEPA, University of Pretoria, SA.
Paavola J. 2004. Livelihoods, Vulnerability and Adaptation to Climate Change in the Morogoro Region, Tanzania. CSERGE Working Paper EDM, No. 04-12.
Ssewanyana S, Kasirye I. 2010. Food Insecurity in Uganda: A Dilemma to Achieving the Hunger Millennium Development Goal. Economic Policy Research Centre (EPRC); Research Series 70. Uganda.
Suryavanshi P, Babu S, Baghel JK, Suryavanshi G. 2012. Impact of climate change on agriculture and their mitigation strategies for food security in agriculture: A review. ISCAJ Biol Sci 1 (3): 72-77. DOI: 10.1186/2048-7010-1-3.
Tambo JA, Abdoulaye T. 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. Reg Env Chang 13 (2): 375-388. DOI: 10.1007/s10113-012-0351-0.
Tenge De Graaff J, Hella JP. 2004. Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. Land Degrad Dev 15 (2): 99-114. DOI: 10.1002/ldr.606.
Twinomugisha B. 2005. A Content Analysis Reports on Climate Change Impacts, Vulnerability and Adaptation in Uganda. DENIVA, Uganda.
Uganda Bureau of Statistics (UBOS). 2009. Uganda Bureau of Statistics, 2009. Statistical Abstracts. Kampala, Uganda.
Uganda Bureau of Statistics (UBOS). 2011. Uganda Bureau of Statistics, 2009. Statistical Abstracts. Kampala, Uganda.
UNEP. 2009. Enhancing the contribution of Weather, Climate and Climate Change to Growth, Employment and Prosperity. UN Environment Programme.
Wambui MB, Opere A, Githaiga MJ, Karanja FK. 2018. Assessing the impacts of climate variability and climate change on biodiversity in Lake Nakuru, Kenya. Bonorowo Wetlands 8: 13-24. DOI: 10.13057/bonorowo/w080102.
Wasige JE. 2009. Assessment of the Impact of Climate Change and Climate Variability on Crop Production in Uganda. Makerere University, Kampala, Uganda.
Yirga CT. 2007. The Dynamics of Soil Degradation and Incentives for Optimal Management in Central Highlands of Ethiopia. [Thesis]. Department of Agricultural Economics, Extension, and Rural Development. University of Pretoria, South Africa.