MAKERERE UNIVERSITY

VULNERABILITY TO CLIMATE CHANGE ON FOOD SECURITY OF SMALLHOLDER FARMERS IN MAHYORO SUB-COUNTY, KAMWENGE DISTRICT, UGANDA.

BY

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A RESEARCH REPORT SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT IN A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF ENVIRONMENTAL SCIENCE AT MAKERERE UNIVERSITY

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DECLARATION.

I hereby declare that this research report is my own original work and it has neither been submitted nor being concurrently submitted to any other institution for any purposes.

Name: KOBUSINGE ROSE

Signature: ..... Date: 19th / 06 / 2018

APPROVAL.

This research report has been developed under my guidance as the University supervisor and is now ready for submission to the Department of Environmental Management for the Degree of Bachelor of Environmental Science of Makerere University with my approval.

PROFESSOR JOHN R.S TABUTI

Signature..... Date.....21/6-18.....

DEDICATION.

I dedicate this work to the Almighty GOD who is always there for me, my family especially my mum Ms. Kellen Komuhangi, The Family of Mr. Edward Muganyizi of Bukoto, my sister Racheal Basemera, Brother Derrick Rwija K, Mr. Mzee Kizito Musa, Mr. Rwija Edward and all my friends for their efforts in my education. It’s for their steadfast love, prayers, and support that have always motivated me and enabled me to progress with this work and in life with minimum complications.

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ABSTRACT.

Sub-Saharan Africa ranks among the most vulnerable regions to climate change and variability. It has the largest proportion of food insecure people where 20% of people are undernourished. Agriculture is the major economic activity for Uganda employing more than 80% of the population, 69% of which practice subsistence agriculture as their main source of livelihood. Agriculture performance fluctuates with changes in weather conditions. This study explored the vulnerability of smallholder farmers and adaptation options to climate change. This study was carried out in Kanyabikere and Katanga villages Kamwenge district with the objectives of: i) to establish the impacts of climate change on food security of smallholder farming community and ii) to identify existing coping and adaptation measures of smallholder farmers to the impacts of climate change on food security. The data was collected using structured questionnaires. The results of the study indicated that all respondents were aware about climate change mainly through personal observations and mass media such as radios. All respondents reported droughts, crop pests especially fall armyworms and bean weevils, abnormality in seasons, increasing temperatures and generally decreased rainfall as major climate change shocks and stresses they experience. These resulted into crop damage, food scarcity, declined yields and water conflicts among others. Respondents practice a wide range of coping and adaptation options such as planting early maturing crop varieties, change in planting dates, and use of pesticides. The limitations to adaptation were; lack of relevant information, materials, and technology to use such as water pumps and limited skills. Respondents appeared to be highly exposed to climate change. Therefore this study concluded that Kanyabikere and Katanga like many other African farming communities are vulnerable to climate change and food insecurity.

1.0: INTRODUCTION.

1.1. Background.

Climate change is a complex global challenge facing humanity today and could undermine the growth and development efforts of developing countries. IPCC fifth assessment report (AR5), defined climate change as, "the statistically substantial changes in climatic properties that endure for an extended period of time". IPCC AR5 indicated that the present changes in the climatic system are the result of human activities. The global mean annual temperatures rose by 0.85^{o}C between 1880 and 2012 and are projected to increase further by 2-4^{o}C by 2100 with significant variability in precipitation.

Vulnerability to climate change includes exposure to climate risks (such as extreme weather events, losses in agricultural productivity and alterations in hydrological patterns), sensitivity to such risks, and capacity to adapt (Perez *et al.*, 2015). From an African perspective, there is evidence of warming patterns across the continent and the increase in temperature is consistent with the increase in greenhouse gases from human activities in the atmosphere. There is an increased frequency of severe extreme weather events such as droughts, floods, and storms (Niang *et al.*, 2014). Africa and Sub-Saharan Africa (SSA) in particular, rank among the most vulnerable regions to climate change and variability. SSA has high levels of climate variability and rain-dependency, high reliance on climate-sensitive activities, regular food crises and water scarcity, rapid population growth, and limited economic and institutional capacity to cope with, and adapt to, climate change and variability. In addition, it is likely that, due to climate change, there will be increases in mean annual temperatures, greater unpredictability of rainfall that is likely to exacerbate existing water shortages, very likely reductions of cereal crop productivity, and surges in disease, pest and weed pressure on crops and livestock (Niang *et al.*, 2014).

Agriculture remains the major economic activity in developing nations. Approximately 90% of the farmers in developing world entirely depend on rain-fed agriculture (Livingston *et al.*, 2011). In East Africa, for example, 85% of the population depends on rain-fed agriculture, which is similar to Zimbabwe (70-80%), Botswana (76%) and Malawi (90%). Farming is the primary source of food and income for Africans and provides up to 60 percent of all jobs on the continent (AGRA, 2015). IPCC AR5 predicts with high confidence that climate change will have significant effects on agriculture production in many African countries. The report continued and projected that by 2020, some of these African country's' production could be reduced by up to

50% with most affected being smallholder farmers and it further points out that climate change could undermine Africa's recent development progress.

Like many developing countries, agriculture is the major economic activity for Uganda employing more than 80, % of the population, 69% of which practice subsistence agriculture as their main source of livelihood. Agriculture performance fluctuates with changes in weather conditions thus far, Ugandans lives and livelihoods dependent on agricultural production which is sensitive to climate change and variability (Twinomugisha, 2005). In Uganda, agriculture is majorly rain-fed with low adaptive capacity to climate change due to inefficient mechanization, high poverty levels as well as inadequate institutional and economic potential. This has amplified the sector's vulnerability to the impacts of climate change.

Climate change will magnify challenges of water stress, reduced crop and animal productivity, changes in incidence and geographical range of vectors and waterborne diseases. These will impose high threats to livelihoods, food security, health and high poverty levels (IPCC AR5) and also, if climate change negatively impacts crop growth, it will leave serious consequences on the level of food production and food security (Huq *et al.,* 2004). Asia has the largest number of food-insecure people while Sub-Saharan Africa has the largest proportion of food insecure people where 20% of people are undernourished in 2010-2012 (Vermeulen, 2014) however, World Bank forecasts show that SSA will surpass Asian as the most food- insecure region. (Harvey *et al.,* 2014) pointed out that there is limited information on the overall vulnerability of farmers to different agricultural risks and the strategies that farmers use to cope with these risks. Therefore this study intends to assess the vulnerability to climate change on food security of smallholder farmers in Kamwenge district guided by research questions like what are farmers exposed to, what are farmers perceptions to climate change and food insecurity, what are their strategies to combat the effects of climate change on food security, and what are the barriers to coping and adaptation to climate change. This will help policymakers to come up with ambitious local strategies that will contribute to international climate change action.

1.2 Problem statement.

East Africa is highly exposed to climate change impacts since it lies astride the equator and it's already hot and dry. In Uganda, the frequency of extreme events such as droughts, erratic rains, floods, and landslides has increased for example between 1991 and 2000, seven droughts were experienced. This has resulted into dependency on food aid for over 10 years due to crop failure year in and out. Climate change will affect all four dimensions of food security, namely food availability (for example, production and trade), access to food, stability of food supplies, and food utilization (Nuwagaba and Namateefu, 2013).

To minimize the severity of climate change impacts on food security, adaptation and vulnerability assessment will play a vital role in protecting agricultural systems. However, in Africa, there are limited agricultural vulnerability assessments and the few that are available generalize information and results are aggregated at national or state levels. This means that participatory vulnerability assessment research that specifically focuses at the local/ community level is still lacking yet according to (Maddison, 2007) there is a difference in the propensity of farmers living in different locations to adapt. Farmers' agriculture zones have unequal propensity and capability to climate change impacts and adaptation, therefore the study of vulnerability and adaptation should continue. However, in Kamwenge, exposure, sensitivity and adaptive capacity of farming households are not known. For this case, this study aims at assessing the vulnerability of smallholder farmers in Kanyabikere and Katanga villages Kamwenge district. This will help policymakers to come up with ambitious local/national and international climate change actions.

1.3 Objectives.

1.3.1 General objective.

To generate information that will enhance food security and improve the resilience of smallholder farmers to climate change.

1.3.2 Specific objectives.

1. To establish the vulnerability to climate change of the farming households of Kanyabikere and Katanga villages.
2. To identify existing coping and adaptation strategies of smallholder farmers to the impacts of climate change on food security

1.4 Research questions.

1. How are farmers exposed to climate change in Mahyoro sub-county Kamwenge district?
2. How are smallholder farmers sensitive to climate change in Mahyoro sub-county Kamwenge district?
3. What are the adaptation strategies to combat the effects of climate change on food security in Mahyoro sub-county Kamwenge district?
4. What are the barriers to smallholder farmers' in coping and adapting to climate change in Mahyoro sub-county Kamwenge district?

1.5 Justification of the study.

The purpose of this study is to generate information that will contribute to the development of relevant adaptation measures. (Füssel, 2007) pointed out that tailoring adaptation practices locally is important. This research can also be used as a guideline for related research in other places. It may also aid individuals, local and national governments, research organizations, NGO's and donors in the struggle to combat the impacts of climate change by aiding the design of appropriate policies and decisions at local or national level. This will reduce susceptibility to climate change impacts by building a climate resilient agricultural sector thus enhancing food security.

2.0: LITERATURE REVIEW.

2.1 Overview of climate change and variability globally and in Uganda.

Scientists have observed changes in Africa's climate during the past century, with records showing increased warming over Africa's land mass. Climate change is already having negative effects on Africa. It is impacting the health of land and marine-based ecosystems, and the health and food security of many of the region's most vulnerable people (IPCC AR5). During this century, temperatures in the African continent are likely to rise more quickly than in other land areas, especially in the arid regions. In East Africa, for example, rainfall is very variable in time and space. A significant increase in temperature since the early 1980s has also been observed in the equatorial and southern parts of Eastern Africa. Several physical processes, including the El Niño Southern Oscillation, affect rainfall. Seasonal average temperatures have also risen in many parts of Eastern Africa in the last 50 years (IPCC AR5). Extreme precipitation changes over Eastern Africa such as droughts and heavy rainfall have been experienced more frequently during the last 30– 60 years and risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development (IPCC AR5).

Temperatures have been increasing in Uganda by approximately 0.2°C/decade over the last 30 years. Recent studies have found a decrease in rainfall during the March-May rainy season (USAID-ARCC, 2013). Uganda climate change vulnerability assessment report pointed out the following climate change projections;

Rainfall:

- The onset of rainy seasons will shift by 15 to 30 days (earlier or later), while the length of the rainy season can change by 20 to 40 days from year to year.
- Increase in rainfall in December, January, and February, which is typically a dry season in all locations. This is most likely to have strong impacts on agriculture, especially tree crops (e.g., coffee) and post-harvest activities such as drying and storage.
- Potential increase in the frequency of extreme events like heavy rainstorms, floods.

Temperature:

- There is an increase in average annual temperatures between 1951-1980 and 1981-2010 by approximately 0.5-1.2^0 C for minimum temperatures and 0.6-0.9 ^{0}C for maximum

temperatures and an increase of more than 2 ^{0}C by 2030. It will likely have a strong impact on agriculture and livestock, increasing the risk of disease and pest infestations.

2.2 Farmers' awareness about climate change.

There is an increasing level of climate change awareness in Africa (Ochieng & Koske, 2013). Research conducted by (Ibeabuchi *et al*., 2017) in Nigeria indicated that majority of Nigerian farmers were fully aware of climate change and its impacts. According to (Muhumuza *et al.,* 2011), a study conducted in Western Uganda, showed that, there are many causes of climate change according to farmers such as deforestation, forest and bush burning and draining of wetlands. Some respondents think that by simply praying to God/god, climate change issues will be solved (Muhumuza *et al.,* 2011). Climate change awareness and information is got from mass media and other local sources. This poses challenges for more robust scientific methods and dissemination of that data, something that needs to be considered by local, regional and international government and policymakers (Ibeabuchi *et al.,* 2017)

2.3 Vulnerability of smallholder farmers to climate change on food security

Africa's vulnerability to climate change is acknowledged in the Third Assessment Report of IPCC 2001. Vulnerability to climate change has been characterized as a function of exposure, sensitivity and adaptive capacity (Nkomo *et al.*, 2006). The poor countries, and particularly the poorest people within them are critically vulnerable to shocks that disrupt their lives and livelihoods. Their poverty increases their vulnerability which limits their ability to cope with and recover from the shocks (Twinomugisha, 2005).

Vulnerability level of the continent largely depends on its current and future adaptive capacities thus the level of economic development, education, access to credit and technology adoption influences adaptive capacity (Hahn *et al.,* 2009). Rampant poverty, weak institutional capacity, lack of skills on climate change adaptability and inadequate skills in disaster management, lack of equipment for disaster management, limited financial resources and above all an economy which depends entirely on exploitation of its natural resources makes Uganda one of the most vulnerable to adverse effects of climate change (Twinomugisha, 2005).

2.3.1 Exposure to climate change.

The long-term climatic change in precipitation and temperature patterns is most likely to increase the frequency of droughts and floods (Kundzewicz et al., 2014). Extreme precipitation changes over Eastern Africa where Uganda belongs such as droughts and heavy rainfall has been experienced more frequently during the last 30– 60 years. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development (IPCC AR5). For example in the period of 1999-2009, four drought episodes were recorded and rain amounts now are reportedly dropping in Kenya. The droughts lead to water stress which is a limiting factor for the people to practice any alternative livelihood activities e.g., growing vegetables, fruits, or raising poultry (Ziervogel et al., 2006).

The agricultural based livelihood systems are already vulnerable to climate change (Ojwang *et al.,* 2010). Across the tropics, smallholder farmers already face numerous risks to their agricultural production, including pest and disease outbreaks, extreme weather events and market shocks, among others, these often undermine their household food and income security (Morton, 2007).

Regional climate model studies suggest drying over most parts of Uganda in the months of August and September by the end of the 21st Century as a result of a weakening Somali jet and Indian monsoon (IPCC AR5). The United Nations Development Program (UNDP) study found that mean annual temperature of the country is projected to increase by 1.0 – 3.1 C by the 2060s. The projections also suggest increases in annual rainfall. USAID's African and Latin American Resilience to Climate change project examined Uganda's Albertine Rift and Karamoja region. As a whole, the country is expected to see temperature rises of more than 2°C by 2030 and rainfall will become more variable, with more rain expected during the dry season (USAID-ARCC, 2013).

2.3.2 Sensitivity to climate change on food security.

There is growing interest in the likely impacts of climate change on agriculture, economic growth and sustainable development in Sub-Saharan Africa. The region is experiencing increased drought in recent times due to increased temperature and reduced rainfall. Incidences of climate change include changes in soil moisture, soil quality, crop resilience, timing/length of

growing seasons, yield of crops and animals, atmospheric temperatures, weed insurgence, flooding, unprecedented droughts, sea level rises and many more (Ozor and Nnaji, 2011).

The high levels of dependence on precipitation for the viability of SSA's agriculture, in combination with observed crop sensitivities to maximum temperatures during the growing season indicate significant climate change risks to the agriculture sector (Lobell *et al.*, 2011). Specific attributes make some households more sensitive to climate change and variability. More vulnerable households are those with many of the following characteristics: Lower proportion of able-bodied (working) members, less well educated, more likely to be headed by female, less likely to sell a portion of their crops or livestock, participate less frequently in community groups such as producer associations, cultural or labour savings groups, and religious organizations; and earn income less frequently from off-farm sources (K Warner *et al.*, 2015).

According to (Muhumuza *et al.*, 2011), farmers are facing several negative effects of climate change like poor crop yields, food scarcity, floods and soil erosion, increase in pests, diseases, and drought, reduced availability of pastures, and soil erosion. Climate change has magnified emergencies of plant pests, which include insects, pathogens, and weeds. These continue to be major constraints to food and agricultural production leading to crop losses significantly worsening food insecurity. The control of plant pests requires use of pesticides, which are usually expensive for the poor farmers and have side effects on human health and the environment (FAO, 2005).

Globally, about 932m people are chronically hungry. Out of 36 countries worldwide facing a problem of food insecurity, 21 are African (United Nations, 2009). Uganda is already experiencing the negative effects of climate change and the situation is expected to worsen as impending calamities will affect agriculture, infrastructure and health (State of Uganda Population Report, 2009). Climate change will impact on food production and availability by affecting food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes. It also impacts on the stability of food supplies by bringing greater fluctuations in crop yields and local food supplies. Food utilization is also impacted on by affecting the ability of individuals to use food effectively by altering the

conditions for food safety and changing the disease pressure from vector, water, and food-borne diseases (Nuwagaba & Namateefu., 2013).

The changes in rainfall will affect distribution and transmission potential of vector and water-borne pathogens (IPCC 2001). For example, cholera – associated with both floods and droughts – may increase with climate change in the Nile River Basin region. Malaria has been identified as the disease most likely to increase because of climate change (Yanda *et al.,* 2006).

Climate change is expected to cause a decline in major cereal crops in Africa but effects will vary with regions according to IPCC AR5. Uganda's crops are vulnerable to projected rising temperatures and rainfall patterns unpredictability, USAID-ARCC, 2013 analyzed the sensitivity of selected eight crops in Uganda on assumptions that temperatures would gradually increase over the next 30 years and current December January February dry season would experience increased light precipitation.

The sensitivity of crops varied with cassava and sweet potatoes showing the least vulnerability and Arabic coffee showing the most. Sorghum, beans, matooke (bananas), maize and rice were moderately vulnerable. Change in crop yield in response to a change in rainfall, change in temperature and the introduction of new crop varieties that are drought, disease, and pest resistant reflects agricultural sensitivity. Due to the high sensitivity of agricultural systems, extensive droughts lead to extensive loss of livestock, for example, the drought of 2009 that took place in Northern Tanzania decimated 55% of the local herds in the sections of Emanyara and Longido. The high sensitivity also brings about food insecurity an example is the 2015 drought that left 67% of Karamojong households lacking food and the remaining 33%, the food stocks were expected to run out in not more than two months. Food insecurity is also indicated by poor children's health which shows up in form of stunting. For instance, more than a third of Ugandan children under the age of five years are stunted (Shinyekwa *et al.,* 2017).

2.3.3 Adaptive capacity of smallholder farmers.

Adaptive capacity is the inherent ability of a livelihood system, or a household, to absorb climate change shocks and to buffer their impacts. It is often described as recovery power, or as a set of assets and strategies that result in livelihood resilience. Coping and adaptation strategies have evolved over time through peoples' long experience in dealing with the known and understood natural variation that they expect in seasons (USAID-ARCC 2013).

The extent to which communities are able to successfully respond to a new set of circumstances that they have not experienced before will depend upon their adaptive capacity (Cooper *et al.*, 2008). (Care International, 2009) pointed out that one of the most important factors shaping the adaptive capacity of individuals, households, and communities is their access to and control over land, natural, human, physical and financial resources.

Adaptive capacity of smallholder farmers to climate change and variability has been reported to be low by different studies because of poor technology, poor infrastructural development, and limited human and natural capital (Cooper *et al.,* 2008). Uganda ranks 159th out 178 countries (2013) which is worse than in 2010 (rank 156) in the ND-GAIN Index which summarizes a country's vulnerability to climate change and other global challenges in a combination of readiness to improve resilience. It ranks 15th on vulnerability and 147th on readiness (USAID-ARCC, 2013). In Uganda, the USAID 2013 assessment concludes that households with greater adaptive capacity manage more diverse agricultural portfolios; they plant more crops and invest in livestock. They also have a more varied mix of on-farm and off-farm income sources and access to land plays a strong role in on-farm diversification.

2.4 Adaptation to the negative impacts of climate change.

2.4.1 Nature of policy on climate change adaptation in Africa.

In Africa, implementation and integration of climate resilient approaches with economic and development planning is limited but growing. Regional, national and sub-national bodies have made progress in developing policy, planning and building institutions for adapting to climate change (IPCC AR5). African governments have developed National Climate Change Response Strategies or, in the least developed countries, National Adaptation Programs of Action (NAPAs). The government of Uganda has established a climate change unit in the ministry of mater and environment to coordinate the interventions and spearhead the policy advocacy efforts related to climate change with support from the Danish government. Mainstreaming climate change in water development and agricultural research are some of the outcomes so far.

Adaptation measures in the action plans tend to focus on agriculture, food security, water resources, forestry and disaster management, and on projects, technical solutions, education and capacity development. National climate-resilient development strategies include Rwanda's national strategy on climate change and low carbon development. Niger, Zambia, and

Mozambique are involved in the pilot program for climate resilience; and, Zambia's sixth national development plan 2011–2015 and the new economic and social investment plan in Niger reflect some integration of climate resilience measures in national development plans (IPCC AR5).

Having signed and ratified the UNFCCC, Uganda has in place the relevant policies and measures which are hoped to effectively address issues of climate change. The major goal of these policies is to achieve poverty reduction through environmentally sustainable development as enshrined in the country's vision for 2040 which mandates poverty eradication action plan. These policies include the vision 2025, poverty eradication action plan, plan for Modernization of Agriculture (PMA), population policy, health policy, disaster management and preparedness policy, forestry policy (2001), climate monitoring, national wetland policy (1995), waste management, energy policy, national water policy and environmental policy (Twinomugisha, 2005). The report identified the following gaps in climate change adaptation and mitigation in Uganda;

- *Lack of policy awareness at various levels of Ugandan society.*
- *Policies are just linked to climate change but not designed to address climate change issues thus climate change issues are downplayed.*
- *There is no holistic policy to govern climate change issues and there is a lot of policy politics in natural resource management.*
- *In many ways, climate change is downplayed and is thought of in the face of disaster.*

2.4.2 Farmer's coping and adaptation strategies to climate change.

Climate change is increasing inter-annual rainfall variability and the frequency of extreme events, leading to accelerated rates of degradation of soil and water resources upon which farming communities depend for their livelihoods (Ojwang *et al.,* 2010). Climate change and variability has negatively affected communities in the past and therefore these communities have responded and developed coping mechanisms to that climate variability (NAPA, 2007).

However, the frequency of events such as droughts, floods and storms was previously low and therefore coping mechanisms were not documented, developed nor popularized (NAPA,2007). The main goal of climate change adaptation is to reduce vulnerability and build resilience to the impacts brought by climate change (Brooks *et al.,* 2004), points out that managing this climate

variability as best as possible is of paramount importance when many other stressors (such as land access, political instability, market Fluctuations, globalization, and HIV/AIDS) enter into the equation.

Many African countries, often with the help of international organizations have responded to the impacts of climate change (IPCC AR5). Examples of adaptation practices on a broad scale are categorized into proactive and reactive adaptation measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early warning systems, insurance, water storage, supplementary irrigation, emergency response, disaster recovery, and migration among communities (Zizinga *et al.*, 2015) .

The common agricultural adaptation strategies used by farmers are the use of drought-resistant varieties of crops, crop diversification, changes in cropping pattern and calendar of planting, conserving soil moisture through appropriate tillage methods, improving irrigation efficiency, and afforestation and agroforestry (Akinnagbe & Irohibe, 2014).

Ojwang *et al.*, 2010 also found out that crop, livestock diversification, mulching, use organic fertilizer, Use of improved varieties, chemical fertilizers and pesticides, agroforestry, drought tolerant and short maturing varieties of crops diversification of income-generating activities, as some of the adaptation strategies to reduce the adverse effect of climate change. Most farmers use these strategies in a combination (Adégnandjou & Barjolle, 2018). Some of the farmers have abandoned crops like pulses, traditional cereal crops, tuber and sweet potato and introduced new crops like spring rice, maize, onion, garlic, cucumber, and cardamom (Neera *et al.*, 2015).

Adaptation strategies that are applied among pastoralists in the Sahel region of Africa include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, and culling of weak livestock for food during periods of drought. During drought periods, pastoralists and agro-pastoralists change from cattle to sheep and goat husbandry as the feed requirements of the later is less than the former (Oba, 1997).

There have been different responses since different regions, places, households are affected differently, and for example, Namibia has battled desertification by using rain-fed pearl millet fields to produce a ground cover that holds the soil between rains. Similarly, the Konso of

Ethiopia, living in one of Africa's hardest climate, have created inter-connected terracing systems that preserve fertile lands (Ground Up, 2007).

2.4.3 Factors that are hindering small holder farmers from adapting to climate change.

Smallholders, while they may be easily adaptable in some ways, also face larger threats and constraints unique or especially intense due to their situation. Smallholders are often diversified across a wider variety of income sources or crops, but they often have low capital with which to adjust to risk and changes (World Bank, 2007). Coping strategies have been passed from generation to generation through traditional and cultural practices. This practice is no longer practicable because of increased frequency and coverage areas. However, widespread poverty that limits adaptation capabilities makes many countries in Sub-Saharan Africa highly vulnerable to the impacts of projected climate change

There are several challenges in attempting to adapt to climate change for example lack of cheap tree seedlings, insufficient land, and limited knowledge on appropriate adaptation technologies. This was proved during the triangulation in the focus group of farmers' group in Nkoma and Mahyoro sub-counties in Kamwenge district (Muhumuza *et al.,* 2011). Also, several studies carried out in Africa pointed out several barriers which challenged the ability of farmers to adapt to climate change with institutional factors, access to credit, lack of information and irregularity of extension services being the main barriers identified (Sutcliffe *et al.,* 2015)

3.0: MATERIALS AND METHODS USED.

3.1 Description of the study area.

Kanyabikere and Katanga villages are found in Kamwenge district. Kamwenge district forms the eastern escarpments of the great Western Rift valley as it descends into the Lake George valley in western Uganda**.** It is located at 0°11'10.0"N, 30°27'14.0"E. It has a total land area of approximately 2,303 km. Generally, the area lies at an altitude in the range of 1300 and 3800m above sea level. The area receives bimodal annual rainfall averaging 1200mm throughout the year for most parts. Kamwenge District has temperatures ranging between 20^0 – 25 ^{0}C (maximum) in most parts. However, during the last two years, the tendency to have erratic rainy seasons has been observed and this has greatly affected agricultural production particularly in the drought-prone areas of Nkoma, Bwizi, Kamwenge, and Nyabbani sub-counties and the rain shadow areas of Mahyoro. Major economic activity is food crop farming with maize, beans, finger millet, groundnuts, cassava, sweet potatoes, Irish potatoes and bananas as the major crops. Major Cash crops grown include coffee in Kitagwenda and parts of Kibale County while Cotton is grown in Mahyoro sub-county. Of recent, there has been a major drive in upland rice growing especially in Mahyoro, Busiriba and Nkoma sub-counties. Fishing is also an economic activity in Mahyoro. The district is predominantly rural and farming is the mainstay for most of the people. The population of Kamwenge was 414,454 as per the census in 2014 (UBOS, 2016). Mahyoro sub-county consists of five parishes.

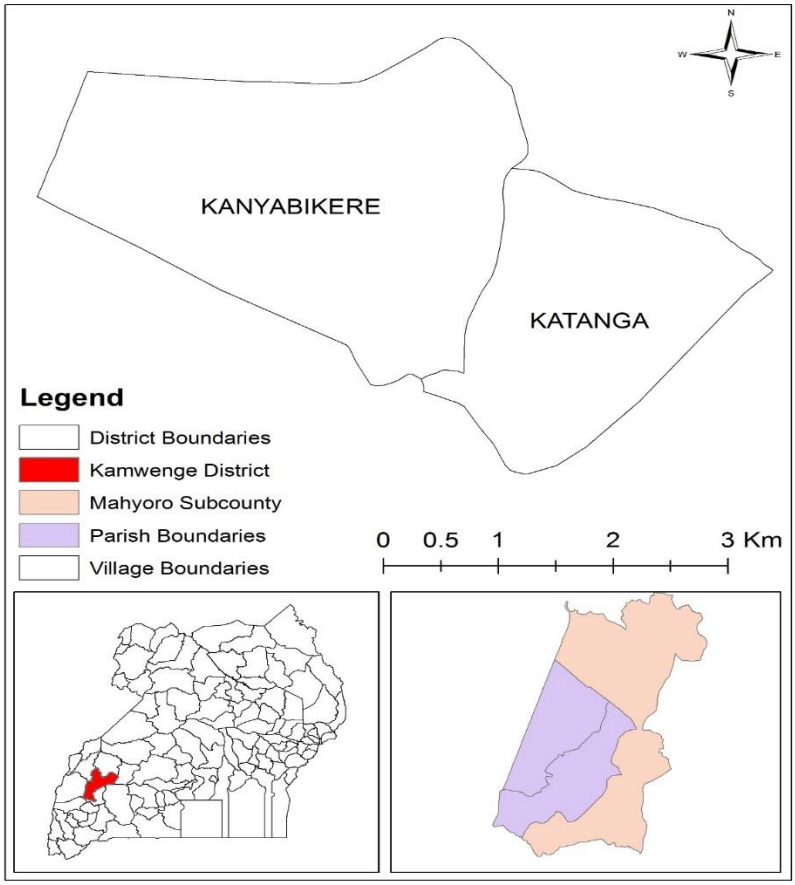

Figure 1: Map of Kanyabikere and Katanga villages in Kamwenge district, Uganda

3.2 Sampling Strategy and Size.

Mahyoro sub-county was randomly selected. The study sample comprised of farming households randomly selected from Kanyabikere and Katanga villages. Sub-county and village leaders were also purposively selected. The sample size comprised of a total of 60 respondents randomly selected with 30 from each of the villages. The sampled farmers had a mixture of different age groups, marital statuses and education levels as shown in the table below.

*Table 1 **:** Demographic-socio-economic characteristics (n=60).*

Variable	Percent	Variable	Percent
Age group		**Highest level of education**	
>65	05	Degree	02
18-35	52	Certificate	05
36-65	43	Secondary school	13
		Primary education	60
Marital status		Never went to school	20
Married	77		
Single	13		
Divorced	08		
Widow	02		

3.3 Methods of field data collection.

Field data was collected by use of a questionnaire (quantitative data) which comprised multiple choice, open and close ended questions for household surveys, question checklist for key informants and keen observation for observable features. For objective i) which was about establishing the vulnerability on climate change of smallholder farmers on food security, respondents were interviewed in face to face interviews. Major questions asked were about which climate shocks and stressors had been experienced, the results from the shocks and stressors, climate change impacts on crop, livestock and food security in the villages. For the objective ii) which was about identifying the existing coping and adaptation strategies to climate change used by the farmers, major questions were about farmers adaptation strategies to the impacts of the climate change to curb food insecurity, what farmers think should be done to help them adapt and the constraints to adaptation. Observation of visible strategies was also used for this objective.

3.4 Data analysis.

The raw data was recorded, cleaned, sorted, organized and analyzed using SPSS package into frequency tables. Pivot table tool in Microsoft Excel was used to sort and summarize data. Graphs and tables in Microsoft Excel were used to showcase the key findings from the study.

4.0: RESULTS.

4.1 Farming systems and climate change awareness by farmers.

Respondents possessed small plots of land which were mostly used for crop farming. Maize and beans were the major crops grown by 93% and 62% respectively. Food scarcity was a big problem faced by all respondents. Most farmers 95% reported a deficit in their food production given their food demand and livelihood requirements as a result of climatic events. This study shows that growing seasons influenced food security. In the first season, farmers reported months of April to June to have the highest cases of food insecurity while in the second season, September to November, were reported. These months are for sowing, weeding, and crop growth before harvesting time. Most respondents reported to have had insufficient food for about six months or more in a year. It was also found out that most respondents (81%) store less than 30% of their total production for food security purposes and sell most of the produce thus worsening food security challenges of households.

This study showed that all respondents are aware of climate change. They think it is real and it is affecting their food security. This is through personal observations, experiences and from the media. Media awareness about climate change is recent as 56% of respondents claimed to have heard from media that the climate is changing only 1 to 2 years ago, 42% indicate 3 to 5 years. Most respondents (77%) have had access to at least some weather and climatic updates in the last one year. Major updates included the start of rainy seasons and planting seasons. The updates are got from a variety of sources including radios, churches, and farmer groups like Mahyoro Twekambe, Kanyabikere Sacco, Kyamuhunga Sacco, and friends. Most respondents (68%) said that radios are the most important ***(figure 2).*** However, some female respondents complained that they have no access to radios since they owned by their husbands.

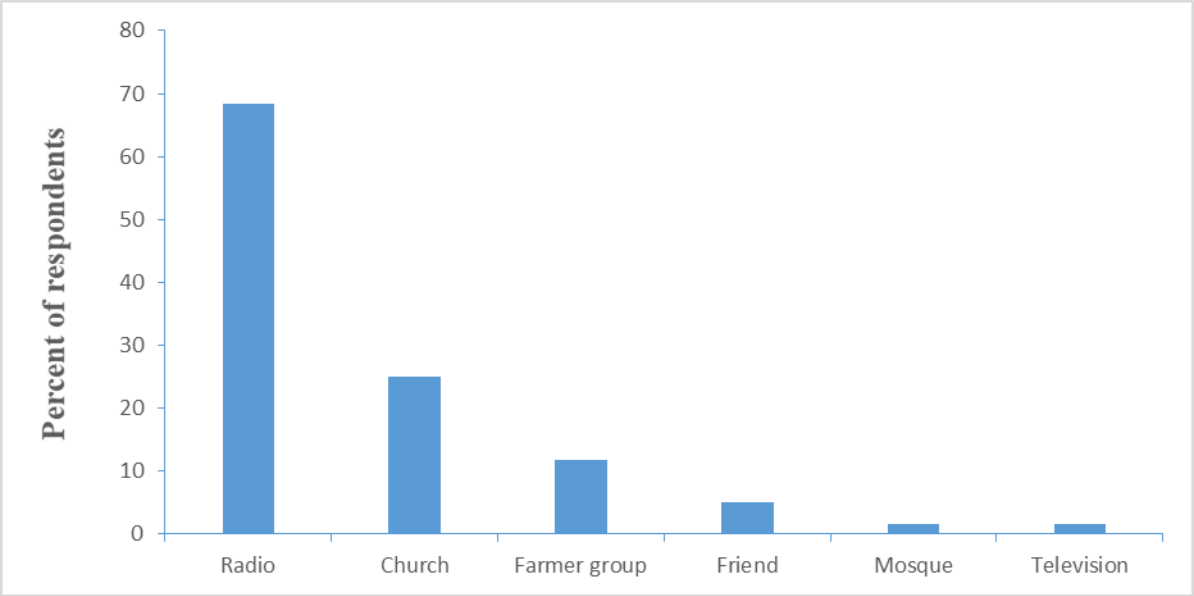

Figure 2: Sources of weather information (n=46).

Most respondents (67%) think that deforestation is the major cause of climate change, 60% said wetland degradation, and 48% said bush burning while the 5% claimed not to be knowing the causes. Some other issues emerged where a small section 3% of respondents mentioned that solar panels cause droughts as they think that panels attract a lot of sunshine and heat which causes droughts while some believed it's God punishing people for their sins by sending droughts, pests **(figure 3).**

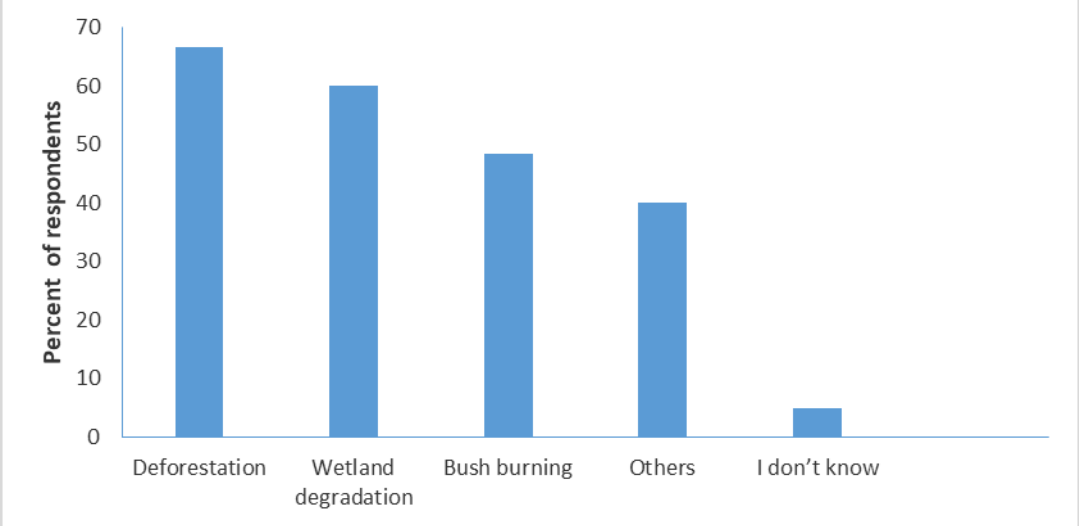

Figure 3: Perceived causes of climate change (n=60).

4.2 Farmers perceptions to exposure to climate change.

Respondents claimed to have been exposed to different climate change and related shocks and stresses. The report by the older farmers was that these shocks and stresses are now more widespread compared to the 1970's. The major ones reported by all respondents (100%) included droughts, increasing temperatures, generally decreased rainfall and greater variability in seasons. All respondents reported that these have resulted into increased crop pests especially fall armyworms and bean weevils, 25% reported animal parasites like ticks **(figure 4).** The perceptions of respondents about seasonal variability varied. All respondents claimed to have experienced longer dry periods and shorter rainy seasons compared to in the past, 72% claimed to have experienced a late start of the first rainy season while 28% claimed an early start of the second rainy season. For rainfall amounts, 70% claimed a decline in the first rainy season while all farmers claimed that the amounts in the second rainy season are not clear **(figure 5).**

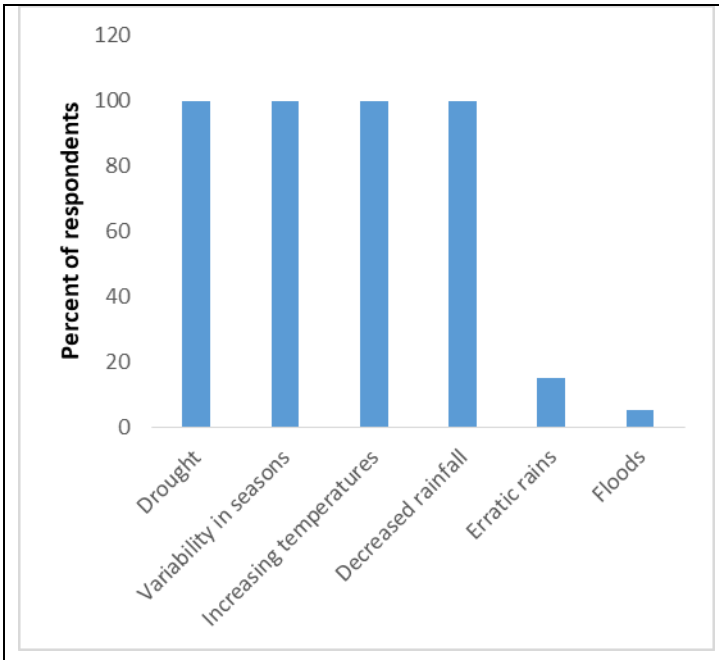

Figure 4: Climate change exposure indicators (n=60).

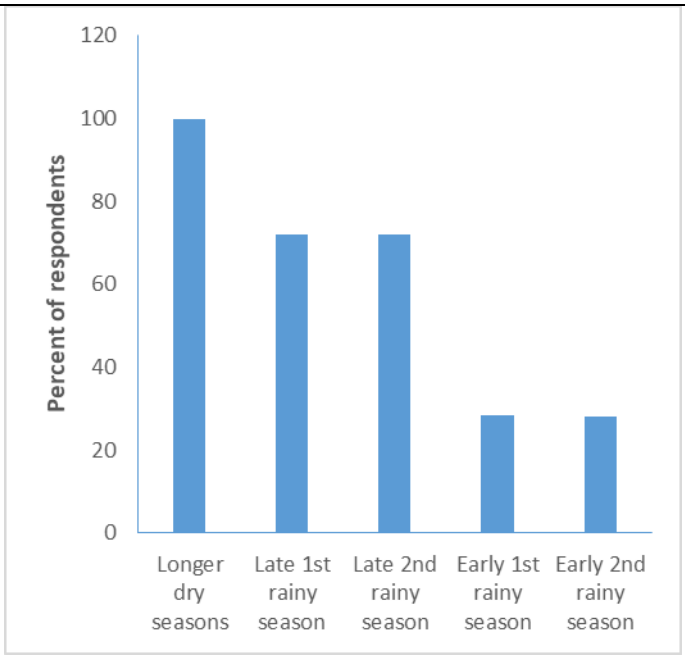

Figure 5: Seasonal variability (n=60).

4.3 Perceived climate change sensitivity on food security of smallholder farmers.

Respondents reported different thoughts on which group of people is more affected by climate change and its impacts. Most respondents (92%) believed that both men, women, and children are equally affected while 5% believe that children are the most affected because of limited access to sufficient nutritious food for growth and loss of livelihoods makes it hard to get school fees. Some few respondents 3%, believed that women are the most affected because of the claimed increased cases of miscarriages attributed to too much heat, poor nutrition, and increased labor demand towards search for household meals as a result from climate change and related impacts

Negative impacts of climate change both direct and indirect have been faced by respondents. The most pressing impacts on crop farmers reported by respondents include drying of crops, increased crop pests and water shortage with 100% and soil erosion due to erratic rains with 33% **(table 2).** These resulted into other impacts like decline in crop yield, food insecurity, increased food prices in market, for example, a small bunch of banana goes for 15000 UGX with all respondents reporting these and loss of income. For respondents who possessed livestock, parasite outbreak was reported by 94%, water scarcity 89%, and a decrease in quality of pasture 83%. These resulted into other impacts such as decline in livestock yields like milk, eggs and meat with all respondents reporting this, loss of income, and death of livestock, especially large livestock like cattle.

Table 2: Effects of climate change on Agriculture.

Climate change effects	**%ge of respondents**	**Climate change effects**	**%ge of respondents**
On Cropping (n=60)		**On Livestock (n=18)**	
Drying of crops	100	Declined livestock yield (eggs, milk)	100
Water scarcity	100	Parasite outbreak	94
Crop pests	98	Water scarcity	89
Reduced soil fertility	60	Decrease in quality of pasture	83
Soil erosion	33	Disease outbreak	83
		Pasture scarcity	78
		Emergency of new diseases	44

Figure 6: Crop failure due to drought (Maize dried before developing cobs)

Figure 7: Coffee trees drying because of drought.

4.4 Adaptive capacity of smallholder farming households.

Agriculture was the major livelihood activity and source of household hold food for all the respondents. Only 30% of the respondents had some livestock, 22% earned some income from trading, 3% from formal employment and 2% from handicraft. Some respondents, 30% were carrying occasional work like digging for others mainly to get food or money. All farmers possessed improved roofs made of iron sheets. The farmers who had livestock owned separate houses from animals. Some respondents 47%, said that they possessed functional small solar systems and 15% had nearby boreholes. Most respondents, 61% owned farmland as individuals and 37% had rented land. The sizes of farmland were generally small as 76% of all respondents had pieces of land between 1 to 4 acres and some had even less than 1 acres **(table 3)**. Some farmers (47%) of the total had access to credit facilities. Some farmers had access to more than one sources. The sources included village Sacco's with 50% and banks 39% **(figure 8).** The credit was mainly used in hiring farmland, buying seeds for planting, pesticides, paying school fees among others. However, the complaint was that limited savings and collateral security implied minimal amounts of credits received.

Table 3: Land ownership (n=60).

Variable	**Percent (%)**	**Variable**	**Percent (%)**
		Size of Farmland	
Mode of farmland ownership		**(acres)**	
Individual ownership	61	<1	12
Rented	37	1 to 4	76
Family land	02	6 to 10	10
		>10	02

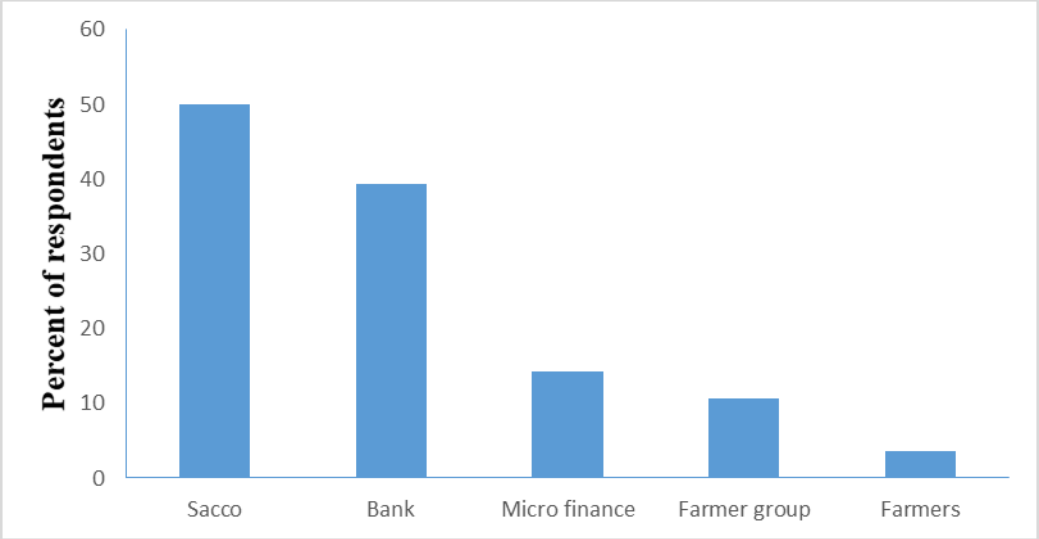

Figure 8: Sources of credit for farming households (n=28).

4.4.2 Social capital of smallholder farmers.

This study shows that only a small proportion of the farmers, 25% of the total had received assistance to recover from the climate change-related shocks at some point. The assistance was in form of food especially maize flour and beans with 36% of these respondents receiving assistance from relatives and friends, 33% from the community groups, less than 10% from others like NGO's and politicians. Some farmers, 27% of the total are engaged in community groups like Saccos and farmer groups. The major groups included Kanyabikere Twekambe, Kyamuhunga Sacco, Mahyoro Twekambe Sacco, Post bank farmers group. These community groups extended services to members such as saving and credit services with 55%, group farming with 23%, giving farming advice 23% and produce bulking 5% where they store produce together during periods of low prices and sell them off during periods of scarcity at higher prices.

4.5 Smallholder Farmers' coping and adaptation strategies.

Farmers reported that they employ a variety of coping and adaptation strategies to deal with negative climate change impacts on food security. For crop production, the most important strategies reported by respondents included planting early maturing crop varieties with 55%, change of planting dates with 48%, and use of pesticides with 47%. Others that were mentioned also included planting crops on lake shores and in swamps due to moist conditions and fertile soils, soil and water management, rainwater harvesting, temporary migration, and mulching.

However, 10% of the farmers claimed to have not done anything as far as climate change adaptation is concerned. Farmers with livestock, 33% of them claimed to have diversified livestock feeds where edible kitchen refuse is always kept for animals, maize stalks and grass is always never wasted, 22% have diversified activities so to survive even when some activities like farming are heavily affected by climate change. Some respondents 22%, claimed to have done nothing to adjust to climate change and related impacts on their livestock enterprises ***(table 4).***

Table 4: Farmers coping and adaptation strategies to climate change impacts.

Coping and adaptation strategies in cropping (n=60)	**Percent of respondents (%)**	**Coping and adaptation strategies in livestock (n=18)**	**Percent of respondents (%)**
Planting early maturing crops	66	change to local drought tolerant breeds	33
Change in planting dates	58	Diversification of activities	22
Use of pesticides	56	Increase in land under livestock	17
Crop diversification	46	Diversification of livestock	11
		Change to local drought tolerant	
Change in crop variety	44	breeds	06
Mixed farming	36	Increase in livestock number	06
Soil and water management	24	Increase in livestock number	06
Watering crops during drought	20	No adaptation	22
Small-scale rainwater			
harvesting	14		
Temporary migration	04		
Mulching	02		
No adaptation	10		

Respondents deal in a narrow base of crops. Major crops grown included maize and beans. 93% of the farmers grow maize, 62% grow beans, and other crops are grown in very small portions **(figure 9).** Respondents claimed that they mostly grow maize because it is a short season crop and relatively withstands water stress conditions, especially after the first two months compared

to other crops that are water demanding. Crops like Bananas, sweet potatoes have been almost completely abandoned. Most farmers who keep livestock reported that they deal in small manageable livestock such that 78% keep goats, 50% keep poultry mostly chicken and only 17% rear pigs and 17% cattle. This was reported that it is because larger livestock like cattle have a high water and pasture demand kept as farmers attributed this to water and pasture scarcity, livestock parasites and diseases which as now prevalent and are attributed to climate change.

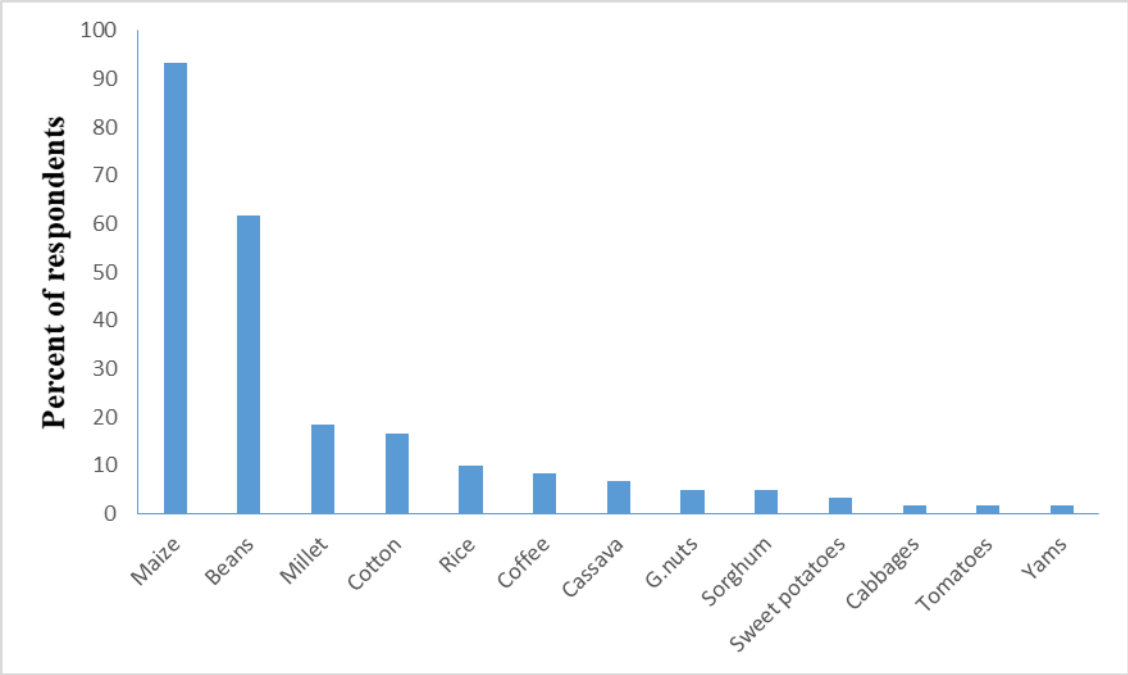

Figure 9: Major crops grown by households (n=60).

Respondents reported to have come up with some coping strategies to manage food dynamics that lead to food insecurity. Most respondents, 98% reported to have reduced number meals taken per day by taking only one or a maximum of two or just having maize porridge for lunch, 30% reported to have reduced the amount of food served per meal especially for the old household members and 17% reported that some household members have abandoned agriculture. Some farmers, 17% reported to have received food from friends, relatives as a way of coping to food insecurity.

Respondents are aware that climate change will continue therefore some have devised long-term plans for adapting and mitigating its impacts. Most respondents, 60% believe that tree planting will help provide shade, add manure to soil, 22% planning to practice agroforestry and pray to

God was also mentioned as some respondents claimed there is a need for divine intervention. However, the 25% of total respondents claim to have nothing planned as far as future climatic changes are concerned.

Figure 10 below shows that farmers also adjusted on their actions and in the way they live as a result of the negative climate change and related impacts. 85% respondents claimed to have reduced the number of meals, 32% believed that they prayed to God to intervene, 30% sold livestock while 12% said they didn't change in any way in response to climate change effects.

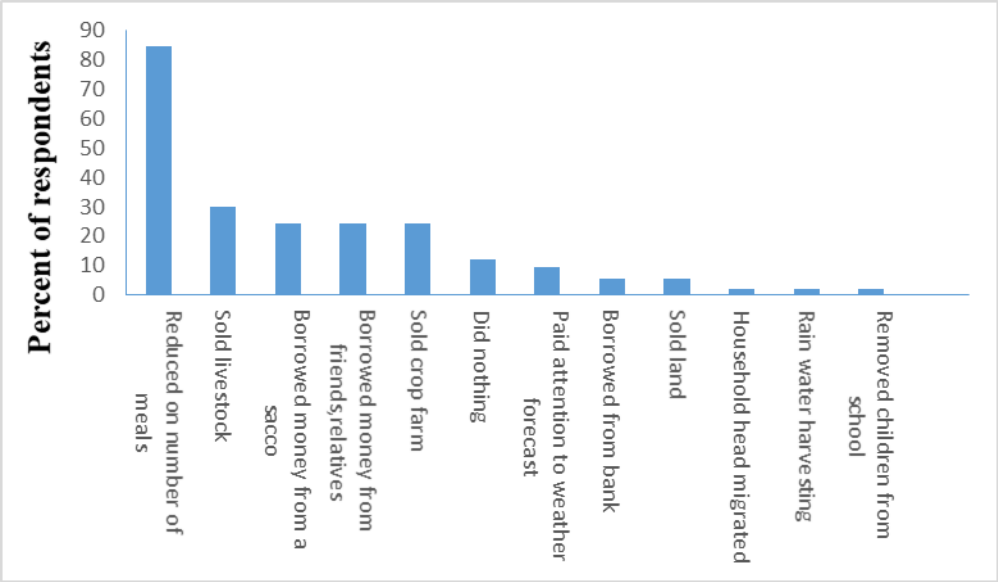

Figure 10: Respondents adjustment in actions due to climate change related impacts (n=60).

4.5.1 Barriers constraining farming households from adapting to the negative impacts of climate change.

Farmers reported that they face constraints while trying to cope and adapt and some of these have prohibited some farmers from adapting. The major constraints included limitations in the availability of relevant information with 100%, limited materials and technology to use such as water pumps, generators for pumping irrigation water from the lake with 98%, and limited skills with 93%. **Figure 11** below shows the barriers that hinder farmers from adapting to impacts of climate change on food security.

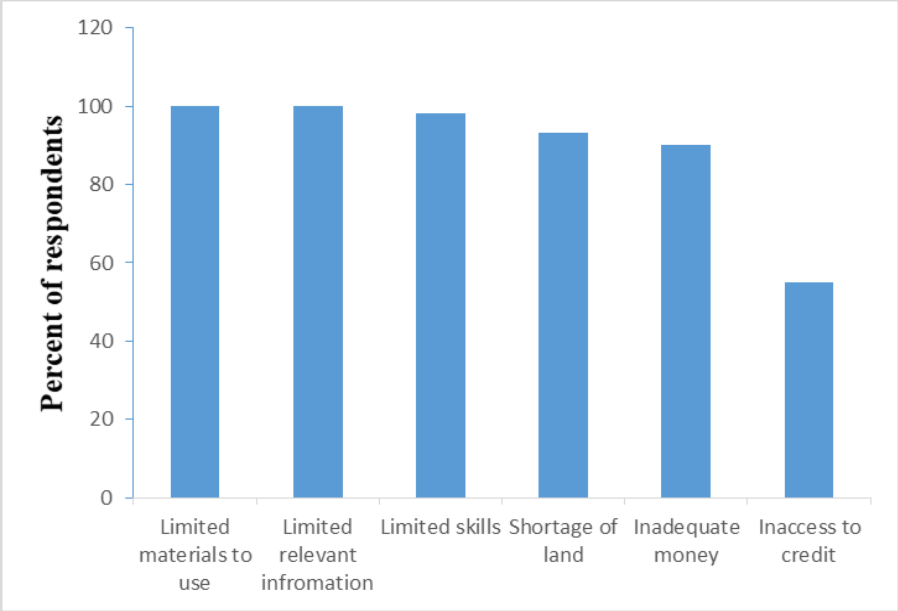

Figure 11: Barriers faced by farming households in climate change adaptation (n=60)

According to respondents, 42% think that helping them to access pesticides at affordable prices such as Striker, Rocket to spray fall armyworm (*Kanyogombwa*), 39% think helping them to access technology to pump water from the lake George for irrigation and use during drought, 33% think that improving accessibility to affordable credit facilities to enable them to purchase inputs ***(table 5)*** will help to improve their adaptive capacity and food security.

Table 5: Respondents ideas on what should be done to improve their adaptive capacity and food security (n=60).

What should be done to improve food security	**Percent of respondents (%)**
Help us access pesticide at affordable prices for pests such as *Kanyogombwa* (fall armyworm)	42
Help us access technology to pump water from the lake for irrigation and use during drought	39
Improve accessibility to affordable credit facilities to aid farmers in purchasing farm inputs	33
Help teach us on better farming methods that are climate smart and improve food productivity	27
Government should support farmers groups to help adapt to climate change and increase production	23
Educate farming households on combined effort on food production	15
Help farmers access land in this region to increase food production	08
Help educate farmers on how to avoid post-harvest losses	03

5.0: DISCUSSION.

5.1 Climate change awareness.

Respondents are aware that the climate is changing. Use of radios is the most effective means of dissemination of climate change and related information since many people can access them. This means that messages should be packaged in the simplest way and disseminated via the media to reach the target audiences. These results match with Ochieng and Koske (2013) who also found out that the level of climate change awareness is increasing in Africa and (Ibeabuchi *et al.,* 2017) who found out that most farmers in Nigeria mentioned mass media like radio as the main source of their climate change knowledge and information.

Most farmers have the correct understanding of the causes of climate change since they related it with high rates of deforestation, wetland degradation and bush burning. This means that their opinions can easily be changed. However, there is some inaccurate information where some few people believe that God is punishing people for the sins committed by sending droughts, pests, while others thought that solar panels attract more sunshine and heat thus contributing to droughts. The results confirm with (Muhumuza *et al.,* 2011), a study made in Western Uganda, which found out that farmers reported deforestation, bush burning and draining of wetlands as major causes of climate change. The study also found out that religious beliefs play a role in perception on issues of climate change because some respondents think that by simply praying to God/god will solve climate change issues.

5.2 Exposure to climate change on food security.

The key elements of exposure are related to increased temperatures, droughts, variability in seasons, erratic rains and increased crop pests like fall armyworm which indeed affected all the respondents that were sampled, bean weevil and maize bore and crop disease outbreak like cotton rust, banana and coffee wilt diseases**.** This exposure contributes to the high sensitivity of crops and farmers' livelihoods by disrupting agricultural activities and it calls for immediate involvement by the government, NGO's, private sector aimed at improving the adaptive capacity of smallholder farmers to reduce their vulnerability to climate change and its impacts. The results match with (Ozor and Nnaji, 2011) who made a study in SSA and found out that droughts have increased, atmospheric temperatures have increased in recent times and rainfall has reduced.

5.3 Sensitivity to climate change on food security and farmers' adaptive capacity.

The major impacts of climate change experienced by farmers included decline in crop yield especially maize and beans, decline in animal productivity in terms of eggs, milk and meat, reduced soil fertility due to erratic rainfall, loss of income, loss of assets and water conflicts. All these contribute to general food scarcity which results into limited choices on food and diet, limited food varieties in the markets, increased food prices in the local markets. This worsens the problems of food scarcity, food insecurity, hunger, stress, and malnutrition in the country. These results match with (Muhumuza *et al.*, 2011) who found out that farmers are facing several negative effects of climate change like poor crop yields, food scarcity, floods and soil erosion, increase in pests, diseases, and drought, reduced availability of pastures, and soil erosion. (Ojwang *et al.*, 2010) also found out that the major impact of droughts on smallholder activities is increased food insecurity and loss of livelihoods.

Results of this study showed that respondents in the study area have a low adaptive capacity due to the low levels of education, limited physical structures and natural capital like land, rainwater tanks, forests, and limited livelihood options since crop farming is the major source of income to all respondents and limited social capital. This means that the farmers' capacity to cope, recover and adapt to impacts of climate change is undermined. These results match with (Cooper *et al.*, 2008) who found out that adaptive capacity of smallholder farmers to climate change and variability has been reported to be low by different studies because of poor technology, poor infrastructural development, and limited human and natural capital

5.4 Existing coping and adaptation strategies to climate change and food insecurity.

Most of the farmers have come up with several means of coping and adapting to the climate change and related impacts. The strategies are mostly used in a combination and include planting early maturing crop varieties, change in planting dates, abandoning high water demanding like bananas, use of pesticides, crop diversification and growing crops in shallow wetlands and on lake shores. All these are carried out with an aim of producing more food for households and for sale. However, there is need for planned adaptation because some farmers reported to have observed no positive results from adaptation. The results match with (Adégnandjou & Barjolle, 2018) who found out that farmers are adapting by crop-livestock diversification, mulching, use of improved varieties, chemical fertilizers and pesticides, drought tolerant and short maturing

varieties of crops. The respondents who possessed livestock have also devised strategies like diversifying livestock feeds, foregoing heavy water and feed demanding livestock like cattle, not throwing away any kitchen refuse eatable by livestock, change in breeds, grazing animals from swamps during droughts. These results match with (Oba, 1997) whose study found out that in the Sahel region of Africa adaptation measures include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate extremes, and culling of weak livestock for food during periods of drought.

In addition to the coping and adaptation strategies in agricultural enterprises, there are other adjustments especially in eating behaviors and lifestyle. These included a reduction in the number of meals taken per day, eating only accessible food like cornmeal and beans, borrowing money to purchase food, seeking food from friends and relatives, while some parents removed children from school for at least a term because of low harvests and income to pay school fees. This implies that respondents are ready to adjust in all ways possible and there is need for proper planning as these adjustments could result into maladaptation. These results match with (Harvey *et al.,* 2014) whose study found out that Farmers use a variety of coping strategies to deal with impacts of climate change on food security, for example, consuming less food, switching diet to the available less desirable foodstuff, borrowing money to buy food, borrowing or seeking food from friends among others.

The results from this study just like several other studies in Africa found out that respondents face several limitations as they try to cope and adapt to climate change. These include limited relevant information especially on climate change adaptation, limited materials to use like mulches, no early warning systems, limited access to improved tolerant varieties, inadequate money since some strategies require purchasing material. This means that adaptive capacity is low and undermines respondents' efforts to adapt. It calls for interventions that will eliminate such problems as a way of improving adaptive capacity and resilience. The results agree with (Muhumuza *et al.,* 2011) who made a study in Mahyoro sub-county and found out that there are several challenges in attempting to adapt to climate change for example lack of cheap tree seedlings, insufficient land, limited knowledge on appropriate adaptation technologies.

According to this study, farmers believed that providing affordable credit, technology, providing extension services, providing affordable agro-inputs like pesticides, fertilizers could improve

their adaptive capacity and enhance food security. This agrees with (Abid *et al.,* 2017) who found out that proper adaptation requires extension services, weather information and water delivery, financial support which increases the adaptive capacity of farmers through an increase in agricultural output or income for the farmers and includes agricultural credit, marketing information, post-harvest processing and the marketing of produce and farm machinery.

6.0: CONCLUSION AND RECOMMENDATIONS.

6.1 Conclusion.

In conclusion, this research has highlighted on the vulnerability and food security conditions of smallholder farmers in Mahyoro sub-county, their exposure to climate shocks, risks, stresses and sensitivity to climate change induced food insecurity, their coping and adaptation options and limitations to coping and adaptation. Given this study, the farmers have a high exposure and sensitivity to climate change while with a very low adaptive capacity due to limited physical, natural, social and financial endowment and they are food insecure. Climate change could be having serious negative impacts on the food security status of smallholder farmers. Therefore smallholder farmers, their crops, and livelihoods are highly vulnerable to climate and its related impacts.

6.2 Recommendations.

Given the results and conclusion from this study, I recommend the following;

Embarking on sensitization of the farmers because to close the information gap as far as climate change and related information is concerned. Early warning systems should be embraced.

Accessible sources such as radios, places of worship like churches, community groups, schools through children and community notice boards should be used to disseminate climate change and related information to improve adaptive capacity.

Governments, NGO's, CBO's and private sector should intervene in activities related to climate change adaptation in order to enhance food security and improve livelihoods because there was no current body handling climate change issues in the area.

Providing affordable technology for irrigation to pump water from the lake to reach gardens and farms. This will farmers to reduce over-reliance on the unreliable rainfall.

Empowering community and farmer groups by providing them with technical and financial support because they seem to be good engines influencing farmers' climate change adaptation activities and decisions.

Provision of affordable credit facilities by banks, microfinance institutions, and livelihood programs to farmers to enable them purchase human and physical resources such solar, big water tanks thus boosting their adaptive capacity to climate change and enhancing food security.

REFERENCES.

Abid, M., Ngaruiya, G., Scheffran, J., & Zulfiqar, F. (2017). *The Role of Social Networks in Agricultural Adaptation to Climate Change*: Implications for Sustainable Agriculture in Pakistan. *Climate*, *5*(4), 85. https://doi.org/10.3390/cli5040085

Adégnandjou, M. R. F., & Barjolle, D. (2018). *Farmers' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Benin*. *Environments 2018, vol 5*(1). https://doi.org/doi:10.3390/environments5010015

Akinnagbe, O. M., & Irohibe, I. J. (2014). *Agricultural adaptation strategies to climate change impacts in africa: a review* Bangladesh J. Agril. Res. 39(3): 407-418.

Alliance for a Green Revolution in Africa (AGRA). (2015). *Africa Agriculture Status Report: Youth in Agriculture in Sub-Saharan Africa. Issue No. 3.* Nairobi, Kenya.

Brooks, N., Adger, W. N., & Kelly, P. M. (2004). *The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation*. *Global Environmental Change*, *15*, 151–163. Retrieved from www.sciencedirect.com

Cooper, P. J. M., Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). *Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa*: An essential first step in adapting to future climate change? *Agriculture, Ecosystems & Environment*, 126(1) 24-35.

FAO. (2005). *31 st Session of the Committee on World Food Security 23-26 May 2005 Special Event on Impact of Climate Change , Pests and Diseases on Food Security and Poverty Reduction Background Document*, (May).

Füssel, H. M. (2007). Vulnerability: *A generally applicable conceptual framework for climate change research*. *Global Environmental Change*, *17(2007)*, 155–167.

Ground Up. (2007). *A PELUM\PSAf publication promoting sustainable development, vol.3No.19*.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). *The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change*—A case study

in Mozambique. Global Environmental Change, *19*(1), 74–88.

Harvey, C. A., Rakotobe, Z. L., Rao, N. S., Dave, R., Razafimahatratra, H., Rabarijohn, R. H., … Harvey, C. A. (2014). *Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar*.

Huq, S., Reid, H., Konate, M., Rahman, A., Sokona, Y., & Crick, F. (2004). *Mainstreaming adaptation to climate change in Least Developed Countries (LDCs). Climate Policy*, *4*(1), 25–43. https://doi.org/10.1080/14693062.2004.9685508

Ibeabuchi Obinna K, Thomas T, Jenkins RE, P. M. and K. K. F. (2017). *Climate Change Impacts, Awareness and Perception of Africa Rural Farming Communities*. *Advances in Crop Science and Technology*.

IPCC. (2013). *Summary for Policymakers. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*

IPCC. (2014). *Climate Change (2014). Impacts, Adaptation, and Vulnerability. Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, … L. L. White, Eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., & Muir-Wood, R. (2014). *Flood risk and climate change: global and regional perspectives. Hydrological Sciences Journal*, *59(1)*, 1–28.

Livingston, G., Schonberger, S., & Delaney, S. (2011). Sub-Saharan Africa : The state of smallholders in agriculture. In *IFAD: International Fund for Agricultural Development: Conference on New Directions for Smallholder Agriculture. 24-25 January, 2011 International* (pp. 1–36). Via Paolo Di Dono, 44, Rome 00142, Italy 1: International Fund for Agricultural Development.

Lobell, D., Schlenker, W., & Costa-Roberts, J. (2011). *Climate trends and global crop production since 1980. Science 333(6042):* 616-620. Retrieved from

https//www.sciencemag.org/content/333/6042/616

Maddison, D. (2007). *The Perception Of And Adaptation To Climate Change In Africa. The World Bank, Policy Research Working Paper* 4308. 53 p. http:// elibrary. worldbank.org/content/working paper/10.1596/1813-9450-4308.

Morton, J. . (2007). T*he impacts of climate change on smallholder and subsistence agriculture. Proc. Natl Acad. Sci.*, 104(50), 19680–19685. https://doi.org/doi:10.1073/ pnas.

Muhumuza, M., Muzinduki, P., & Hyeroba, G. (2016). *Small holder farmers' knowledge and adaptation to climate change in the Rwenzori region*.

Neera, S. ., Sijapati, S., & Bajracharya, S. . (2015). *Farmers' responses to climate change impact on water availability: Insights from the Indrawati Basin in Nepal*.

Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padghan, J., & Urquhart, P. (2014). *Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* (Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nkomo, J. C., Nyong, A. O., & Kulindwa, K. (2006). *The impacts of climate change in Africa, Final Draft Submitted to The Stern Review on the Economics of Climate Change*.

Nuwagaba, A., & Namateefu, L. K. (2013). *Climatic Change , Land Use and Food Security in Uganda*": A Survey of Western Uganda. *Journal of Earth Sciences and Geotechnical Engineering*, *3*(2), 61–72.

Oba, G. (1997). *Pastoralists' traditional drought coping strategies in Northern Kenya. A report for the government of the Netherlands and the government of Kenya,*. Euroconsult BV, Arnheim and Acacia Consultants Ltd, Nairobi.

Ochieng, M., & Koske, J. (2013). *The Level of Climate Change Awareness and Perception among Primary School Teachers in Kisumu Municipality, Kenya.Ochieng, M. & Koske, J., (2013). The Level of Climate Change Awareness and Perception among Primary School Teachers in Kisumu Municipality, Ke. Nternational Journal of Humanities and Social Science, vol 3*(21), pp.174–179.

Ojwang Gordon. O., Agatsiva Jaspat and Situma Charles (2010). *Analysis of Climate Change and Variability Risks in the Smallholder Sector. Case studies of the Laikipia and Narok Districts representing major agro-ecological zones in Kenya*. Department of Resource Surveys and Remote Sensing (DRSRS) in collaboration with the Food and Agriculture Organization of the United Nations, Rome..

Perez, C., Jones, E. M., Kristjanson, P., Cramer, L., Thornton, P. K., Förch, W., & Barahona, C. (2015). *How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective*. *Global Environmental Change*, *34*, 95–107. https://doi.org/10.1016/j.gloenvcha.2015.06.003

Sutcliffe, C., Dougill, A. J., & Quinn, C. H. (2015). *Evidence and perceptions of rainfall change in Malawi: Do maize cultivar choices enhance climate change adaptation in sub-Saharan* Africa? *Regional Environmental Change*, *16*(4), 1215–1224. https://doi.org/10.1007/s10113-015-0842-x

UBOS. (2016). *National Population and Housing Census 2014*. *Uganda Bureau of Statistics, Main Report , Kampala, Uganda*. Retrieved from http://documents.worldbank.org/curated/en/2013/02/17235637/opening-doors-gender-equality-development-middle-east-north-africa

Uganda National Adaptation Programmes of Action (NAPA). (2007). *Uganda National Adaptation Programmes of Action (NAPA)*. (L. Ms Florence, Y. Dr. Moyini, O. Mr. Samuel, & R. Mr. Mukotani, Eds.).

United Nations (UN). (2009). *Food security in Africa: learning lessons from the food crisis.* United Nations Conference on Trade and Development.

USAID-ARCC 2013. (2013). *Uganda Climate Change Vulnerability Assessment*. *United States Agency for International Development (USAID)*. Retrieved from http://www.usaid.gov

Warner, K., De, L., Brouwer, M., Bodegom, A., Pluie, B., Galema, F., & Buit, G. (2015). *Climate Change Profile Uganda*. Netherlands. Retrieved from https://ees.kuleuven.be/klimos/toolkit/documents/686_CC_uganda.pdf

Warner, K., Ehrhart, C., Sherbinin, A. de, Adamo, S., & Chai-Onn, T. (2009). *In search of*

shelter: Mapping the Effects of Climate Change on Human Migration and Displacement. *United Nations University, CARE, Columbia University*. London. Retrieved from http://internationalstudies.uchicago.edu/outreach/summerinstitute/2011/documents/sti2011-warner-pping_the_effects_of_climate_change_on_human_migration_and_displacement.pdf

World Bank. (2007). *World Development Report 2008: Agriculture for Development.* Washington, DC.

Yanda, P., Wandiga, S., Kangalawe, R., Opondo, M., Olago, D., Githeko, A., … P. Achola, P. (2006). *Adaptation to Climate Change/Variability-Induced Highland Malaria and Cholera in the Lake Victoria Region* (No. AIACC Working Paper). Washington, District of Columbia.

Ziervogel, G. Nyong, A . Balgis, O. Conde, C. Cortés, S. and Tom, D. (2006). *Climate Variability and Change:Implications for Household Food Security*. *AIACC Working Paper No. 20*.

Zizinga, A., Tenywa, M., Majaliwa, J., Mugarura, M., Ababo, P., Achom, A., … Adipala, E. (2015). *Potential Climate Change Adaptation and Coping Practices for Agricultural Productivity in the Mountain Areas of South Western Uganda*. *Journal of Scientific Research and Reports*, *7*(1), 23–41. https://doi.org/10.9734/JSRR/2015/16351

APPENDICES

Appendix 1: Questionnaire

Dear respondent, my name is Kobusinge Rose a student of Makerere University doing my undergraduate research in climate change vulnerability on food security in Mahyoro sub-county Kamwenge district for Bachelors of environmental science. I humbly request you to cooperate with me and fill in the questions as required. The information you will provide shall be kept confidential and used only for academic purposes. Thank you very much for your precious time.

Before we start, do you have any questions?

SECTION A: IDENTIFICATION

<table>
<tr><td colspan="5">1. Interviewer's name_____</td></tr>
<tr><td>2. Respondent's sex</td><td>Male</td><td>Female</td><td></td><td>3. Age in years. 1. 18-35 2. 36-65 3. >65</td></tr>
<tr><td>4. Marital status</td><td colspan="4">1. Single 2. Married 3. Divorced 4. Widow 5. Widower</td></tr>
<tr><td colspan="3">5. District:</td><td colspan="2">7. Sub- County</td></tr>
<tr><td colspan="5">6. Village</td></tr>
<tr><td colspan="5">SECTION B: LIVELIHOOD CHARACTERISTICS</td></tr>
<tr><td colspan="3">8. What is the highest level of education completed
1. Never went to school 2. Primary school
3. Secondary school 4. Certificate
5. Diploma 6. Degree
7. Others _____(please state)</td><td colspan="2">9. How many persons live in your household?
Male above 17 – 35 years:
_____
Female above 17 – 35 years:
_____
35 years and above: _____</td></tr>
<tr><td colspan="3">10. Do you possess any of these structures?
1. Improved food store 2. traditional granary
3. Tapped water 4. Water tank> 500ltrs
5. Solar 6. Separate house from animals</td><td colspan="2">11. What are the main sources of income in your household
1. Crop farming 2. Trading
3. Livestock farming 4. Forestry
5. Bee farming 6. Handicraft</td></tr>
</table>

7. Nearby borehole/tap 8. Other (specify) ……	7. Fishing 8. Remittances 9. formal employment 10. Others (specify) …….
12a. Do you own land? 1. Yes, 2.no. if yes, b. What is your overall land size (acres) 1 <1 2 1-5 3 6-10 4 >10	13. What is the size of farmed land in (acres) 1 <1 2 1-5 3 6-10 4 >10
14. Is the farmland yours or rented 1. Owned 2. Rented Others (specify)……..	15. What is the tenure of most of your cultivated land? 1. Mailo Land 2. Freehold 3. Leasehold 3. Customary land 4. Others (specify)…….

SECTION C Have you observed the following climate change-related impacts in last decade?: PERCEPTIONS OF FARMERS AND IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY (OBJECTIVE 1)

1. a. Have you heard about climate change? b. If yes, for long have known about it?	Yes | No 1. 1-2 years 2. 3-5 years 3. >6 years
2. Which changes in temperatures have you observed in the past 10 years	1 Increase 2 Decrease 3 No change 4 Don't know
3. Which changes in rainfall have you observed in the past 10 years	1 Increase 2 Decrease 3 No change 4 Don't know
4. Have you experienced any changes in the growing seasons	1 Late rainy season 2 Early rainy season 3 No change 4 Don't know
5. Have you observed the following climate change related impacts in last decade?	
6. Whom do you think is more affected by climate change-related impacts (circle all that which apply)	1. Women 2. Children 3. Elderly 4. Men 5. All 5. I don't know
7. What do you think could be the causes of the changing climate?	1. Deforestation 2. Industrialization 3. Bush burning 4. Gods wish 5. Wetland degradation 6. I don't know 7. Others (specify)……..

Climate related impact	**Yes**	**No**
1 Decline in crop yield		
2 Increase in crop yields		
3 Decline in livestock yields		
4 Increase in livestock production		
5 Death of livestock due to shortage of fodder and water		
6 Food shortage /insecurity		
7 Increased disease and pest pressures		
8. Water conflicts		
9. shrinking vegetation		
10. Reduction of water in sources (e.g rivers, streams, dams, wells, boreholes)		

Crop production

8a.Do you grow crops? 1. Yes 2. No

b. Which crops does your household mainly produce?

……. ……

c. What Percent of food do you keep for household consumption? …….

d. What Percent is for sale? ……..

e. Show during which months of the year when you have enough food or less food to feed your family. In addition, show the major source of food.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC

Key for; 1. Enough, 2. Shortage

Key for source; (a) own farm, (b).mainly off-farm e.g. purchase, aid

Livestock production

9a. Do you keep Livestock? 1. Yes 2.No

b. Which Livestock do you mainly keep? 1. Cattle 2.goats 3.pigs 4.poultry 5.others (specify)……..

c. What is the Percent of the livestock or livestock products are for home consumption or for sale?

Home consumption…… Sale ……..

10. How has climate change affected the availability, accessibility, utilization and stability of the food system for your household? (Tick all that apply) 1. Reduced food from my farm 2. Increased food prices that I cannot sustain food demand 3.Reduced number of meals due to inadequate resources 4. Sometimes some members miss meals because of food inadequacy 5.sometimes even in market you cannot buy whatever food you want 6. We don't normally have a balanced 7. I or some household members don't access a balanced diet 8. I or some household members eat food we don't want 9.malnutrition has increased in children 10. Other family members have given up on food production thus reducing output and stability of food at home.

11. What do you think should be done to improve food security in your area?....……

12. How has climate change manifested itself in this area? (Circle all that which apply) 1. Drought 2. Flood 3. Erratic rainfall 4. Hailstorms 5. Landslide 6. Others (Specify)……..….	13.Which year(s) was the shock (state year for each shock)	14. What were the results from shock 1. loss of asset 2. loss of income 3. Decline in crop yield 4. death of livestock 5. food shortage 6. water shortage 7. increased food prices 9.conflicts & wrangles 10.removed children from school 11. Others……	15. Who helped you to overcome the shocks? 1.none 2.relatives 3. friends 4.community group, 5.govt, 6.NGOs 7.politicians, 8. Religious bodies 9. Others (specify)…….	16. What kind of assistance did you get?

SECTION D

COPING AND ADAPTATION STRATEGIES ON FOOD SECURITY OF SMALLHOLDER FARMERS TO CLIMATE CHANGE (OBJECTIVE TWO)

17. How has climate change affected your **CROPPING** enterprise? 1. Decrease in yields 2. Increase in yields 3. Flooding of crop farms 4. Destruction by hailstorm 5. Drying of crops 6. Crop failure 7. Reduced soil fertility 8. Soil erosion 9. Pest and disease stress e.g 10. Change in seasons 11.Others(specify)	18. What strategy do you use to adapt to the negative climate change-related impacts to your **CROPPING** enterprise 1 Buying insurance 2 Change crop variety 3 Mixed farming 4 Temporary migration 5 Planting early maturing crop 6 Soil and water management 7 Irrigation 8 Changing planting dates 9 Seek off-farm employment 10 Crop diversification 11 Change in planting date 12 Plant of short season variety 13 Water harvesting 14 No adaptation 15 Other (specify) ----------
19. How has climate change impacted on **LIVESTOCK** farming 1. Water scarcity 2. Pasture scarcity 3. Parasite outbreak 4. Disease outbreak 5. Emergency of new diseases 6.Decrease in quality of pasture 7.Decrease in animal productivity 8. Others (specify)…….	20. What strategies do you use to adapt to the negative climate-related impacts to your **LIVESTOCK** enterprise 1. Do nothing, 2. increase livestock number 3. Increase land under livestock 4. Diversification of activities 5. Diversification of livestock 6. Diversification of livestock feeds 7. Change in breeds 8. dipping 9. Vaccinating 10. shift from livestock to crop production 11. Opted for off-farm activities 12. Others (specify) ……..

21. What are some of the adaptation barriers that you face?	22. What other actions have you undertaken as a result of climate change related impacts(tick all that apply)
1. Inadequate money 2. Limited relevant information 3. Limited materials to use 4. Limited skills 5. shortage of land 6. in access to credit 7. measures don't apply here 8. Others (specify)……	1.Did nothing 2.paid attention to weather forecast, 3.sold livestock 4.sold crop farm 5.gave my daughter in marriage 6.sold land 7.borrowed money from friends, relatives 8 got money from a Sacco 9. Borrowed from bank 10. Removed children from school 11. Prayed 12.reduced on number of meals 13.household head migrated 14. Gave up on farming 15. Others (specify) ……

23. The impacts of climate change are expected to worsen, what long-term strategies are you likely to implement to improve food security…… ……

24a.Have you received any weather updates in the last year?	b. If yes, what was the source 1.Radio 2.Tv 3.church 4.Newspaper 5.NGO 6.radio 7.friend 8.farmer group 9. Others (specify)……	25a.Do you access credit facilities?	b.If yes, from which source	26a. Do you or any household member belong to any community group(s)?	b. If yes, what's the name of the group(s)	27.And what activities do they carry out
1. Yes 2. No		1.yes 2.no	1. Bank 2.microfinance, 3.farmers 4. Farmer group 5.sacco 6.others	1. Yes 2. No	…… …….. ……	…… …… ……

Appendix 2: Key informant interview questions

1. a. Have you heard about climate change?
   b. If yes, for how long have known about it?
2. a. Have you heard about climate change?
   b. If yes, for how long have known about it?
3. What do you think could be the causes of the changing climate?
4. Which changes in temperatures have you observed in the past 10 years
5. Which changes in rainfall have you observed in the past 10 years
6. Has the growing season changed? If yes, how so?
7. Whom do you think is more affected by climate change-related impacts?
8. What climate change-related disasters have you observed in your area in the last 10 years?
9. In which year did you experience each of the disasters mentioned above?
10. What kind of assistance did you get to recover from the mentioned disasters?
11. What is the state of food security in your area?
12. What climate change-related impacts on food security have you experienced in your area?
13. What crops or livestock have been or being abandoned in your area because of climate change-related impacts?
14. Do you have institutions dealing with climate change risks in this area? If yes, specify them and the strategies they have introduced in your area?
15. Are farmers responding positively to the introduced strategies?
16. What interventions by governments, CBO's/NGO's could improve smallholder farmers' adaptation to climate change to improve food security in this area?
17. What do you think could be the causes of the changing climate?
18. Which changes in temperatures have you observed in the past 10 years
19. Which changes in rainfall have you observed in the past 10 years
20. Has the growing season changed? If yes, how so?
21. Whom do you think is more affected by climate change related impacts?
22. What climate change related disasters have you observed in your area in the last 10 years?

23. In which year did you experience each of the disasters mentioned above?
24. What kind of assistance did you get to recover from the mentioned disasters?
25. What is the state of food security in your area?
26. What climate change related impacts on food security have you experienced in your area?
27. What crops or livestock have been or being abandoned in your area because of climate change related impacts?
28. Do you have institutions dealing with climate change risks in this area? If yes, specify them and the strategies they have introduced in your area?
29. Are farmers responding positively to the introduced strategies?
30. What interventions by governments, CBO's/NGO's could improve smallholder farmers' adaptation to climate change to improve food security in this area?