

**An assessment of the effect of climate resilient agricultural practices towards food security
in Oruchinga Camp-Isingiro District**

BY

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Declaration

I, **Beinomugisha Boris**, do declare that this dissertation titled "An assessment of the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District" is my original work and that no part or the whole of it has ever been submitted to any other institution for any award.

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Approval

This research dissertation titled "An assessment of the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District" has been submitted to the department of agriculture, agribusiness and environmental sciences Bishop Stuart University for examination with my approval as University research supervisor.

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Dedication

I wish to dedicate this work to my beloved parents, family, co-workers and friends who have been the pillars behind my success today because of their social, financial and moral support rendered to me, their constant prayers and comfort which all contributed greatly towards the end of my dissertation.

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LIST OF ABBREVIATIONS

AOR:	An adjusted Odd Ratio
CA:	Conservation Agriculture
CMG:	Collaborative Marketing Group
CRA:	Climate resilient agriculture
CRAFT:	Climate Resilient Agri-businesses for Tomorrow
CSA:	Climate Smart Agriculture
FAO:	Food and Agriculture Organisation
FICCF:	Finance Innovation for Climate Change Fund
GDP:	Gross Domestic Product
GHS:	Greenhouse gases
IDPs:	Internally Displaced Persons
IFAD:	International Fund for Agricultural Development
IPCC:	Intergovernmental Panel on Climate Change
IPM:	Integrated Pest Management
UNDP:	United Nations Development Programme
UNFPA:	United Nations Fund for Population Activities
UNHCR:	United Nations High Commissioner for Refugees
UNICEF:	United Nations Children's Fund
USAID:	United States Agency for International Development
WASH:	Water Sanitation and Hygiene
WFP:	World Food Programme

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Abstract

This study was about assessing the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District. Climate-resilient agricultural practices are the approaches that includes sustainability with existing natural resources through crop and livestock production systems to achieve long-term higher productivity and farm incomes under climate variability. The study established the different climate resilient agricultural practices used by smallholder farmers within the settlement camp, determine the effect of selected climate resilient agricultural practices on the food production systems of the local's, establish the potential factors limiting the adoption of climate resilient agricultural practices and recommend available adaptation possibilities that can aid craft resilience to climate change and variability. The study employed both qualitative and quantitative approaches for data collection. Information was gathered from a sample of 322 respondents and 10 key informants using self-administered questionnaire and interviews respectively. Data was analyzed using Microsoft EXCEL 2016 and SPSS Version 21.0 was used to run t-test to generate both descriptive and inferential statistics. The study identified the different climate resilient agricultural practices used by smallholder farmers within the settlement camp such as; agro forestry, use of improved crop varieties and livestock breeds, water-smart technologies, soil fertility management, use of compost and organic pesticides and small scale irrigation. The study also found out that climate resilient agricultural practices like agro forestry, water-smart technologies, use of improved crop varieties, soil fertility management and use of compost and organic pesticides had a statistically significant effect on food production systems in the camp. The study further found out that capacity building through training and skills development, agroforestry promotion, promotion of labour saving technologies, promotion of climate resistant crop and animal varieties, increasing water supply, boosting community education and awareness programs, integrated pest and disease control as well as widening extension coverage could be adaptation possibilities that could aid craft resilience to climate change and variability in the area. In conclusion, the study confirmed that there are different climate resilient agricultural practices being used by farmers in the area and these practices have significantly supported food production systems. The small sized land was one of the main reasons why farmers fail to use recommended CRA practices, therefore increasing on production per unit area through opening new arable land areas would mean that farmers have enough spaces to try new technologies/practices.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

FAO (2015) defines climate-resilient agriculture (CRA) is an approach that includes sustainability with existing natural resources through crop and livestock production systems to achieve long-term higher productivity and farm incomes under climate variability, it differs from climate smart agriculture (CRA) that, climate smart agriculture (CRA) is too advanced and smart that it doesn't allow any adverse situation of climate change over ecology as well as productivity. Climate resilient agriculture (CRA) is an inbuilt mechanism of the system to recognition the threats that need to be responded to, with effectiveness (Ademola et al., 2016).

Food security is the measure of an individual's ability to access food that is nutritious and sufficient in quantity (Ruel et al., 2017). The concept of food security can be broken down into four main components known as the four pillars of food security' including availability that refers to the existence of food within a community, access that refers to having enough food in a community, Utilization that includes having the utilities to properly select, prepare, and store foods that are available and accessible, as well as food stability which means that access, availability and utilization of food remains relatively stable over time.

Globally, climate change remains a threat to food security systems and one of biggest challenges in the 21st century (FAO, 2015). It was widely accepted that the ability to contain the pace of climate change by keeping change in temperature rise within 2°C threshold in the long run was limited and the global population had to deal with its consequences (IPCC, 2014). Agricultural production systems are expected to produce food for the global population that is expected to reach 9.1 billion people in 2050 and over 10 billion by end of the century (World Bank, 2021). According to Dinesh and Vermeulen, (2016), agricultural systems need to be transformed to

increase the productive capacity and stability of smallholder agricultural production in the wake of climate change. This change has already caused significant impacts on water resources, human health and food security (Mbuli et al., 2021). Rising temperatures and changes in rainfall patterns affect agricultural production with significant decline in crop and livestock production.

Africa has warmed about half a degree over the last century and the average annual temperature is likely to rise by an average of 1.5-4°C by 2099 (IPCC, 2014). World Bank (2021) notes that Africa is becoming the most exposed region in the world to impacts of climate change. It is claimed that sub-Saharan Africa is currently the most food-insecure region in the world (FAO, IFAD, & UNICEF, 2020).

The current food insecurity problems are attributed to several factors, including largely frequent droughts associated with changes in climate patterns. In most parts of Africa there is high costs of food production due to high costs of inputs especially fertilizer, displacement of a large number of farmers in the high potential agricultural areas due to wars and political violence, high global food prices and low purchasing power for large proportion of the population due to high poverty levels of poverty. Climate change could aggravate the situation further unless adequate measures are put in place (FAO, IFAD, & UNICEF, 2020).

According to Chandra & McNamara (2018) transforming the traditional agricultural techniques, which prioritize productivity and show less concern on environmental degradation, into CRA, which enhances food security by conserving natural resources, requires improving the synergies and reducing the trade-offs between agricultural productivity and natural resources management. The ability to prepare for climate disturbance, recovering from shocks and distress, and grow from destructive experiences is defined as climate resilience (World Bank, 2021; Bernier et al., 2015). Climate resilience through CRA practices can be developed by utilizing ecosystem

services. For instance, farmers implement agroforestry that combines trees and shrubs in forests and gardens. On one side, this technique gives direct benefits to the farmers, such as improving their income and diversifying food productivity if the trees are food crops. On the other side, it provides merits to the environment, such as preventing erosion, increasing the infiltration rate and biodiversity, and balancing the ecosystem (Aune, 2020). These advantages enable farmers to be more flexible to cope with nuisances in their surrounding areas due to climate change.

In East Africa, poverty reduction and food security improvement in vulnerable areas are among the many challenges that governments face (Dessie et al., 2019). Governments constantly face a trade-off between food production which generates significant amounts of greenhouse gas (GHG) and mitigation of climate change which requires reduction in some agricultural activities (Canevari-Luzardo, 2019). For instance, ruminant production contributes a significant amount of methane gas to the atmosphere, yet it is an important exercise to meet the food demand and income for farmers (BFS/USAID, 2017). Addressing these antagonistic objectives has proved challenging. Many ecosystem services, including nutrient cycling, nitrogen fixation, soil regeneration and biological control of pests and weeds, are under threat in food production systems and have had serious implications on smallholder sustainable food security. Climate change adaptation is therefore highly necessary to cope with the inherent challenges which are hampering food productivity. CRA practices are seen as the means to achieve resilience at the same time reducing environmental degradation.

In Uganda, climate change is quite evident indicated by a continuous rise in temperature and change in rainfall patterns (Amin et al., 2015). Irregular rainfall patterns continue to be experienced with intense downpours causing floods in many parts which appear in cycles with severe droughts. Specifically, both day and night temperatures have significantly been on a rising

trend since the 1960s. For instance, the night temperature (minimum) has risen by 0.7–2.0 °C and the day temperature (maximum) by 0.2–1.3 °C, depending on the season and the region (Eshete et al., 2020). These unprecedented changes in climate have accompanied losses that have already been experienced in the country (FAO & UNDP, 2018). For instance, evidence indicates that between 2015 and 2019 droughts in Uganda caused damages equivalent to 2.4% of gross domestic product (GDP) (Atube et al., 2021). The report further indicates that the projected annual cost of climate change impacts would be in the tune of USD 1–3 billion by the year 2030 (Atube et al., 2021).

Majority of smallholder farmers in Uganda depend on agriculture for survival (Jassogne et al., 2013). Building their adaptive capacity and resilience to climate change is key to enable them protect their livelihoods while ensuring food security. The ability to cope with the impacts of weather shocks and natural disasters brought by the effects of climate change depends largely on the household's resilience, or its capacity to absorb the impact of, and recover from, a shock (Dekens et al., 2012). One way of combatting the effects of climate change is through climate resilient agricultural (CRA) practices (Ogada et al., 2014). Promoters of CRA adoption seek to sustainably increase agricultural productivity and incomes by building resilience through adapting to changes in climate and reducing and/or removing GHGs emissions relative to conventional practices (Jaramillo et al., 2013). However, factors like poverty, weak institutions and under-investment in key sectors remain critical in Uganda's ability to cope with climate change.

In Oruchiga refugee settlement camp climate change is evident with its effects on crops and livestock production significantly experienced (Atube et al., 2021). It has contributed to high poverty level in the camp which is currently at 35.9% compared to the country level of 21.4%

(FAO, 2017). The major effects of climate change include loss of quality and quantity of natural biodiversity, soil erosion and flooding. Varying rainfall patterns have affected both land preparation and food production leading to lower yields (Atube et al., 2021). Similarly, occasional rise in temperature affects moisture retention by soil which leads to wilting of crops hence lower yields contributing to food insecurity. Climate change adaptation has therefore been highly necessary to cope with the inherent challenges hampering food productivity. CRA practices have been promoted as means to achieve resilience at the same time reducing environmental degradation. However, there is still low adaptive capacity of these practices which continuously affect the food security and income levels of the growing refugee population in the camp (Atube et al., 2021).

1.2 Statement of the problem

With over 132 million people on the verge of being undernourished, 1/3 of the food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (IPC, 2017).

In East and Southern Africa, food insecurity continues to rise because of several reasons including ongoing conflicts and extreme weather events. An estimated 75 million people will be food insecure by October 2024 (World Bank, 2024).

In Uganda, the proportion of food secure population (phase 1) has declined from 83% in July 2016 to 69% in January 2017. An estimated 10.9 million people are experiencing acute food insecurity (phase 2 and 3), of which 1.6 million (5%) are in a crisis situation (phase 3). Those in phase 3 are found in Central (0.58 million); Karamoja (0.12 million), Teso (0.2 million), East Central (0.38million) and South Western (0.31 million) regions. All regions in the country have a combined food security stressed population of 9.3 million (26%) (IPC, 2017).

Uganda has witnessed a general decline in food production and access in the recent years (FAO & UNDP, 2018). Since 2008, the country has been witnessing severe food insecurity problems in refugee settlements depicted by a high proportion (87%) of the population having no access to food in the right amounts and quality (Atube et al., 2021). United Nations High Commission for Refugees (UNCHR) report 2021 indicated that more than one hundred thousand refugees were food insecure of whom 65.7% solely depend on food relief (Atube et al., 2021). To combat the food insecurity situation in refugee settlements including Oruchiga refugee settlement camp, Government in collaboration with UNHCR and NEMA promoted the implementation of CRA strategies to cope with the effects of climate change on food systems (Atube et al., 2021). These include: agroforestry and carbon trading, awareness creation on rain water harvesting and water management practices. Additionally, methods like crop diversification, adoption of drought/pest resistant crop varieties and seeds, shifting to bio-fuels for domestic and industrial use, sustainable land use, encouraging mitigation through non-forestry activities such as fuel-switching and energy efficiency as well as use of bio-fuels. Despite the multiple benefits of CRA practices and the deliberate efforts by the government and development partners to encourage farmers to invest in them, there is still a lack of evidence on how these CRA practices contribute to household food security given the rising cases of hunger and malnutrition in the settlement. In addition, CRA practices have been more applicable in more developed countries with advanced technology and favorable land use policies compared to the current study area where farmers only rely on less advanced practices like agroforestry, tillage, water conservation, and organic manure application to encounter climate change effects. Thus, a detailed understanding of farmers' adoption of current CRA practices and their potential effect on food security in rural setting like Oruchinga camp is important in informing policy makers and other development

partners on the practical strategies they could champion to enhance usage and effectiveness of CRA practices in smallholder production systems.

1.3 Objectives of the study

1.3.1 General objective

The main objective of the study is to assess the effect of climate resilient agricultural practices on household food security and recommend the best or a combination of practices that can contribute sustainable food security in Oruchinga camp-Isingiro District.

1.3.2 Specific objectives

1. To establish the different climate resilient agricultural practices adopted by small holder farmers in Oruchinga.
2. To establish the potential factors limiting the adoption of climate resilient agricultural practices in Oruchinga.
3. To determine the effect of selected climate resilient agricultural practices on the food production systems.
4. To identify possible strategies of enhancing CRA practices in Oruchinga.

1.4 Research questions

1. What are the different climate resilient agricultural practices adopted by small holder farmers in Oruchinga?
2. What are the potential factors limiting the adoption of climate resilient agricultural practices in Oruchinga?
3. What is the effect of selected climate resilient agricultural practices on the food production systems?
4. What are the possible strategies of enhancing CRA practices in Oruchinga?

1.5 Justification of the study

Climate change poses threats to local food production and family wellbeing resulting in malnutrition, hunger, and persistent poverty in different parts of Uganda such as Isingiro (Atube et al., 2021). Climate resilient agriculture (CRA) is one of the approaches of adapting and coping with the challenges of climate change. It is important because of its triple potential benefits including improved productivity, high income returns, reduction or removal of greenhouse gases as well as improved household food security. Although the government and other stakeholders have promoted a number of CRA practices in some areas of Isingiro district, there is a dearth of knowledge on how these practices affect household food security and drivers of the choice and use of the CRA practices. Although farmers may adopt several CRA practices or a combination of practices, it is not clear which specific practice or a combination gives the highest payoffs in terms of improved food security. As such, this study is geared towards filling this knowledge gaps by a descriptive cross-sectional study among small scale farmers in Oruchiga settlement camp Isingiro district.

1.6 Scope of the study

The scope of the study was categorized into geographical, content and time as discussed below;

1.6.1 Geographical scope

The study was carried out around Oruchinga refugee settlement in Isingiro District in southern Uganda. The settlement was started in 1959 as a transit camp for refugees of Rwandese origin who were affected by tribal clashes in Rwanda. Presently the refugee settlement hosts more than 8000 refugees from Burundi, DRC and Rwanda. Its current size was eight square kilometers with 15 villages. According to the given statistics the settlement was not receiving new refugees, apart from family reunification, referrals and protection cases. Agriculture was the main economic

activity in the area with emphasis on food crops like; sweet potatoes, beans, cassava, maize, bananas, groundnuts, onions and cabbage. The study area was chosen basing on the fact that witnessed continuous food shortages resulting from declined agricultural output due to changes in temperature and rainfall patterns (UNHCR, 2014).

1.6.2 Content scope

The study focused on climate resilient agricultural practices and food security. Whereby the independent variable was climate resilient agricultural practices and food security was a dependent variable. However, much emphasis was put on establishing; the different climate resilient agricultural practices adopted by small holder farmers, the potential factors limiting the adoption of climate resilient agricultural practices, effects of climate resilient agricultural practices on the food production systems as well as possible strategies of enhancing CRA practices.

1.6.3 Time scope

The study used secondary literature for a period of 8 years (that is 2013 – 2021). It was within this this period that Government embarked on promoting climate change adaptive mechanisms to sustain production in refugee settlements with an aim of alleviating food insecurity and poverty at household level.

1.7 Significance of the study

Research was conducted to analyze the effect of climate resilient agricultural practices on household food security among smallholder farmers in Oruchinga refugee camp. The finding of the study produced vital information about agribusiness practices used in refugee community to ensure food security. The study revealed the factors that hindered adoption of climate resilient

agricultural practices by smallholder farmers in Oruchinga among which included lack of information about CRA practices. For that matter therefore, the findings of this study may be helpful to government, NGOs, agricultural extension services as well as community members of the camp as discussed below;

Study results may help the government through the Ministry of Agriculture, animal industry and fisheries by using this research to disseminate information on the appropriate climate resilient practice that can enhance production which can enable smallholder farmers to obtain sustainable food security in their households.

Study findings may be used by the community members who would wish to start agricultural projects in the area by helping them acquire necessary information on climate change adaptive mechanisms needed to sustain food crop production.

Different stakeholders like NGOs dealing with refugee communities and agricultural extension workers may use the study results sensitizing the farmers about appropriate CRA practices that can contribute to the overall agricultural boost hence attaining food security, poverty reduction, and improved livelihoods of smallholder farmers.

The study contributed to the body of literature on the efforts towards adaptation to adverse effects of climate change in agriculture sector and provided invaluable information necessary for ongoing policy development with regard to mainstreaming climate resilient practices in the Agriculture sector of Uganda. This study further provided invaluable information for researchers in developing improved systems to ensure that their experimental systems are appropriate for farmers' needs, abilities, and circumstances. Finally, the study results may help farmers to make informed climate resilient practices adoption decisions that require considerable resources, skills, and time to implement and manage.

Findings and recommendations of this study generated both practical and theoretical awareness important to other researchers, policy formulators, policy implementers, Cooperative Societies and agricultural stakeholders in revitalizing the sector.

1.8 Conceptual framework

The framework demonstrates a set of relationships among independent variables, intervening and dependent variables. In this context, background and independent variables influence dependent variable. Climate resilient agricultural practices such as agroforestry, soil fertility management, tolerant cropping, organic farming (independent variables) contribute to improved crop production and performance. Moreover, climate resilient agricultural practices tend to boost soil nutrients which eventually increases crop output resulting in improved food security (dependent variable). However, the influence the independent variables have on the dependent variable rely on moderating factors such as household characteristics, nature of soils, geographical location, level of deforestation, industrialization and agricultural policies in place.

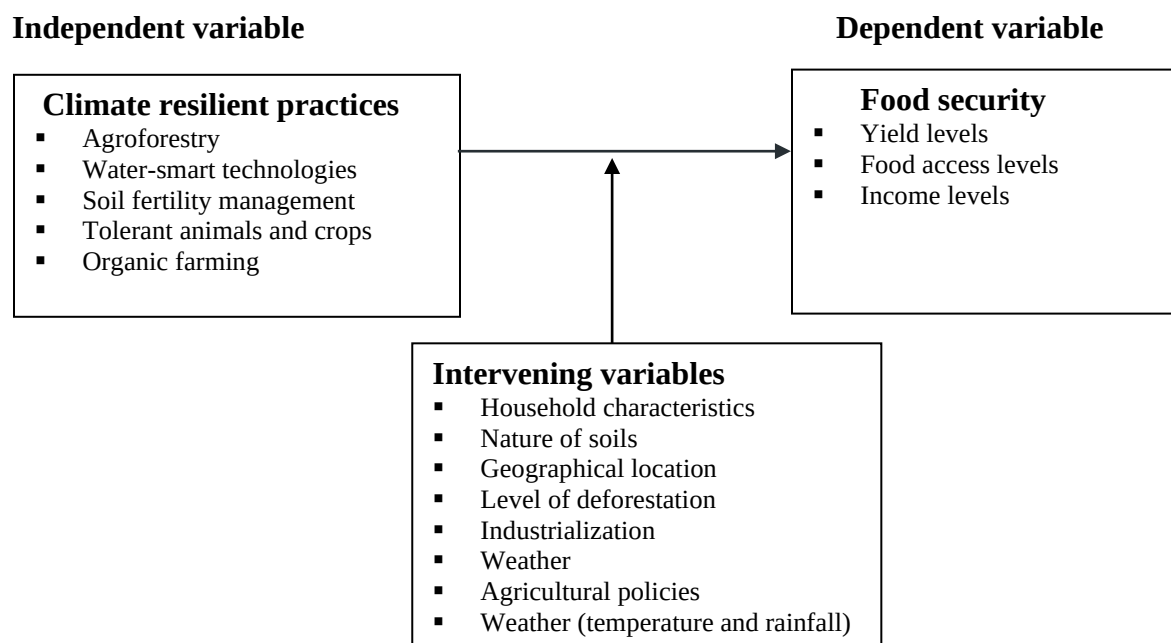


Figure 1.1: Conceptual framework above represents the relationship between climate resilient agricultural practices and household food security

1.9 Definition of Key Terms

Climate: Climate encompasses the statistic of temperature, humidity, atmospheric pressure, wind, rainfall atmospheric particles count and other meteorological elements in a given region over the long period of time (Ho & Shimada, 2019).

Climate change: Climate change refers to natural and or human induced changes in the mean and/or the variability of climate properties and that persists for an extended period, typically decades or longer (IPCC, 2014).

Climate variability: Climate variability can be defined as temporary changes in climatic components such as precipitation, temperature, humidity and atmospheric pressure.

Resilience: The ability of small scale farmers to recover from shocks resulting from climate variability and change due to knowledge and skills of farming operations based on climate information and smart technologies (IPCC, 2014).

Climate resilient Agriculture: An approach towards food security and socioeconomic development based on three pillars: enhancement of productivity and earnings, improvement of resilience of livelihoods and ecosystems and mitigating and removal of greenhouse emissions from the atmosphere (FAO, 2017).

Climate resilient Practices: Practices adopted in farming systems under climate smart agriculture that enhances sustainable agricultural production while responding to climate change challenges (FAO, 2017).

Small scale farmers: are farmers who own 5 acres or less living and practicing farming in the study area

Food security: refers to access by all people in a socially acceptable means at all times to nutritionally adequate and safe food for an active and a healthy life (Anderegg et al., 2019).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter explored literature on the effect of climate resilient agricultural practices on household food security. It examined key concepts and reviews secondary information on the food security situation among households, climate resilient agricultural practices adopted by smallholder farmers, effect of climate resilient agriculture practices on the food production systems, potential factors limiting the adoption of climate resilient agricultural practices and available adaptation possibilities that aid craft resilience to climate change and variability for smallholder farmers.

2.2 Theoretical framework

This study was hinged on an evolutionary theory. The theory emphasizes on the reaction of actors in response to their learning and knowledge. The adaptation actions to climate change by different actors at different levels is part of this reaction to the predetermined knowledge and learning (Assefa et al., 2019). This includes for example farmers' perception of climate change and other actors or partners' knowledge of climate change. This coordinated action between actors to respond to changes leads to a third category of contribution of evolutionary theory. This is the tradition of links and interdependencies among sectors and actors. These boundaries of links and interdependencies are not fixed but changes over time. Sector wise, from the study area for instance, sustaining agricultural food supply is decreasing while in other areas it is increasing, which creates mixed reactions at some point (Assefa et al., 2019). Accordingly, actors and their interaction also change (Jones & Tanner, 2016). The last group of contribution of evolutionary theory considered in this study is the system of innovation approach, which considers innovation as an iterative process among wide variety of actors. This includes how the actors in the

adaptation process to the different sectors such as agriculture of the study area interact. This considers innovation as a collective process.

In connection to the evolutionary theory and systems of innovation approach, with emphasis on interactive learning and actors' interaction, qualitative studies often find that the sensitivity of agricultural systems to climate are rarely attributed to solely changes in some exposure, or in the adaptive capacities to respond to the exposure, as assumed in crop models; instead sensitivities can be seen as pathways over time (Buckle, 2020). Farmers' cognition and social institutions are considered as the basics in adaptation steps to climate change (Belay et al., 2017). Having understood the climate has indeed altered, and strategies are imperative, farmers then, need to identify potentially useful and feasible innovative adaptation strategies for implementation.

Abera & Tesema, (2019) assert that adaptation to climate change is a multi-faceted progress which therefore creates farmers adaptive capacity. The process of adaptation requires four elements notably, the cognitive and behavioral change of farmers, technical implementation of series of appropriate practices and investments, the institutional and organizational arrangement towards adaptation, and temporary or permanent migration. Abera & Tesema, (2019) further explained the steps in adaptation as limits to adaptation providing how thus impedes capacity to adapt.

The system of innovation perspective in adapting to changes considers knowledge as a strategic and fundamental capital for innovation (Harvey et al., 2018). This is not, however, the only requirement for successful adaptation. The innovation process actually comprises five elements. Farmers' knowledge, which includes farmers' first exposure and information to innovation about the technology, or tool, while the second element, farmers' persuasion is the process, where farmers develop a kind of interest, and mind setup towards adoption of the technology, but may

or may not require additional information, or asset base (Harvey et al., 2018). These levels, such as exposure and persuasion are the elements of perception towards the change, and need for adaptation. Farmers' decision, a kind of balance to weight the advantages and disadvantages of the technology, cost-benefit analysis, and an inclination towards adoption or rejection of the technology is determinant for implementation, while at the implementation stage; farmers employ the innovation to varying degrees depending on different opportunities, and decision results. In general terms, the decision, and implementation of adaptation of strategies depend on the way farmers perceive the changes, and whether strategies are imperative. Farmers' perceptions of climatic changes have to be, therefore, center of such adaptation planning studies (Herlina & Prasetyorini, 2020).

Though the theory emphasizes on farmers' perceptions of climatic change to be center of adaptation to CRA practices to enhance food productivity, there are other factors that affect adoption to an innovation, which the current study intends to address.

2.3 Climate resilient agriculture (CRA)

Climate resilient agriculture (CRA) is a sustainable approach for converting and reorienting agricultural systems to support food security under the new realities of climate change through different adaptation and mitigation mechanisms (Mlenga & Maseko, 2015). Agricultural systems are extremely vulnerable to climate change, given their sensitivity to variations in different threats like temperature, precipitation and incidence of natural events and disasters such as droughts and floods with this on an average the extreme weather patterns can impact farm incomes in the range of 15-18 %. Threats can be reduced by increasing the adaptive capacity of farmers as well as increasing resilience and resource use efficiency in agricultural production systems (Adela et al., 2019). CRA promotes synchronized actions by farmers, government,

scientist, private sector, and policy-makers through three main action areas: (1) Building the capacity to identify the threats; (2) Curing the threats through adaptation and mitigation process (3) Sustain their adaptive mechanisms over a long time. Since, agriculture is vulnerable to climate change, the intensity of the problem for example droughts and floods may prompt smallholder farmers to adopt CRA practices as they promise to solve the problem of agriculture being vulnerable to natural threats as mentioned.

According to Ballard et al. (2018), climate-resilient agriculture (CRA) include 3 phases, i.e. 1 *Recognition Phase*: “System recognize its adverse threats quickly”. Such threats include event such as erratic rainfall, cyclone, drought, flood, heat or cold wave, long dry spell, frost, insect and pest outbreaks and other threats caused by climate change. It is also known as initial phase of CRA. 2 *Curing Phase*: “System cure itself through different adaptive and mitigative mechanisms”. Such mechanism includes conservation agriculture, cover crops, integrated farming system, carbon sequestration, direct seeded rice, precision farming, site specific nutrient management. It is the intermediate phase of CRA. 3 *Sustaining Phase*: “System should sustain their adaptive mechanisms over a long time”. CRA with these mechanisms building itself in such a way that it can break through any hurdle that would come its way. It is the final phase of CRA.

Studies on CRA, shows that CRA phases that is; recognition phase, curing phase, and suitability phase are of great importance contributing to the overall sustainability and productivity of food production even in threatened-climate regions. These studies are therefore relevant to the study because it improves the capacity of smallholder farmers to have sustainable food security.

2.4 Food security situation of community living in refugee settlements

According to United Nations High Commission for Refugees Uganda (2014), Uganda is host to refugees and asylum seekers from several countries with the majority from South Sudan (62%), the Democratic Republic of Congo (DRC) (29%), Burundi (3%) and Somalia (3%). They leave their countries in search of protection from several factors, mostly conflict related. By the end of February 2021, the total number of refugees and asylum-seekers in Uganda was 1,462,164, with 81% of them being women and children (Atube et al., 2021). Most of the refugees live in settlements and host communities in the West Nile, Mid-West and South West sub-regions of Uganda. The existence of refugees and the influx of new arrival asylum-seekers into Uganda increases demand for essential services and exerts pressure on common resources in both refugee settlements and host communities. Delivery of services to both refugees and host communities not only serves to stabilize, build self-reliance and resilience to shocks, but also helps to strengthen the peaceful coexistence between the two populations (Maitra et al., 2019). The Government of Uganda (GoU) with support of Humanitarian and Development actors (UNHCR, WFP, UNICEF, FAO, UNFPA, partner organizations et al.) provides basic services to the Persons of Concerns (PoCs) which include health and nutrition services, food and non-food items, Water, Sanitation and Hygiene (WASH) services, education, fuel, shelter, and economic inclusion (FAO 2017). However, the problem of food insecurity in the refugee settlements is continuously increasing. Hence, a justification for the study that was done in Oruchinga Refugee settlement.

United Nations High Commission for Refugees Uganda (2014) stated that in the early 2000's, food assistance remained the key source of food stocks among refugees. More than 93 percent of refugee households depended on food aid for their food stocks. The continued decline in

households depending on own production food stocks was attributed to poor harvest in addition to very dry seasons (January to March and June to September). In addition, less dependence on market was attributed to an increase in average retail prices for key staple food/commodities. Food assistance was the only means through which many refugees met their food needs (Atube et al., 2021). According to researcher's own view most refugees depend on food aid because they do not have adequate allocated land for agriculture and agriculture requires investment costs which also hinder asylum seekers to engage in farming.

According to United Nations Office of the Special Adviser on Africa (2016), the overall food security situation of the refugees in Uganda improved compared to the early 2000's where they solely depended on food reliefs. This was because good distribution and performance of the 1st season rains of March to July resulted into increased production. Although, there was a problem of food insecurity in Oruchinga refugee camp, United Nations Office of the Special Adviser on Africa confirms that in 2016, the refugee camps in Uganda had adequate food. Therefore, this rising problem of food insecurity can be attributed to increasing number of asylum seekers year by year.

Generally, an improvement in the food security situation of the country has been registered from 2012 -2020 with refugee populations moving from humanitarian Emergency phases to a non-Emergency phases (Atube et al., 2021). It should be noted that these populations are on borderline or moderately food insecure, which implies that appropriate responses and strategies are still necessary to increase resistance and resilience of livelihood systems by reducing the risk to hazards and addressing structural hindrances (such as access to Health, education, water and sanitation) that would prevent these populations from slipping back into humanitarian phases and ensure increased production and household food sustainability in future.

According to Atube et al. (2021) refugee camps in Northern Uganda got improvement in agricultural production. The food security situation is slowly becoming stable. The good performance of the first rains, of March to July 2010, resulted in above average harvests for some households. This increased income earning opportunities to meet basic food needs and led to decline in prices of common food products as the supply of food commodities to markets increased (Atube et al., 2021). First season harvesting of cassava, sweet potatoes, beans, millet and simsim continued to increase market supplies, household food availability, and access. Own production contributed most to household consumption followed by market purchase hence reliance on food aid, gifts and donations declined. The increase in food production increased in northern Uganda hence leaving other Refugee settlements in other regions food insecure. Hence, a justification for the study conducted in Oruchinga refugee settlement in Isingiro district western Uganda.

According to Kpadonou et al. (2017), the key factors limiting crop food crop production in settlement areas are inadequate access to planting materials and inability to increase acreage under crop production, due to limited resources to pay for additional labour and lack of tools to clear land that had been crop-free for more than two decades during the conflicts. Although there are several factors hindering adoption of CRA practices in refugee camps, inability to increase the acreage is among the major predictors. This is because the demarcations were designed long time ago and the number of asylum seekers increase day by day hence making farmers unable to increase their farm acreages.

2.5 Climate resilient agricultural practices used to boost food security in refugee camps

According to Olawuyi, (2020) climate-resilient agriculture includes proven practical techniques and approaches that can help achieve a triple win for food security, adaptation and mitigation. For example, by increasing the organic content of the soil through conservation tillage, its water holding capacity increases, making yields more resilient and reducing erosion. Climate-resilient agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage on farmland (Shanabhoga, 2020).

Soil resilience; improve soil health, a key property in building crop resilience under climate change. Building soil carbon, reducing erosion, and increasing water retention capacity of soil are important factors that improve resilience. Soil testing for balanced nutrient application and improved application techniques can lead to synergy in crop requirements and emission reduction (Osumba et al., 2020). However, the scholars did not elaborate how soil health can be improved. Therefore, the study was conducted to reveal different ways of improving soil health addition of compost and organic manure which increase water retention capacity of the soil and this improved soil resilience.

Adaptation of tolerant crop varieties. According to Susanti et al., (2018) it involves the adoption of seed varieties that are drought, heat, and flood-resistant to achieve consistency in yields and better productivity. Adaptation of tolerant crop varieties has to be done in conjunction with the farming community at a local level depending on weather projections and planning as drought tolerant crops enhance food production during the dry season when food insecurity levels are highest. However, the scholar did not mention some of the tolerant crop varieties that should be

adopted in areas vulnerable to climate changes. Hence, the study was done to identify some of the tolerable crops that should be grown in refugee settlements.

Conservation tillage. Adapt to the use of conservation tillage practices for minimal physical loosening of the soil (Olayide and Kyle, 2017). This leads to an increase in soil organic matter and creates an ecosystem for crops to thrive. The researcher agrees with the scholars because conservation tillage leads to reduced greenhouse emissions, leading to a reduced carbon footprint.

Soil Fertility Management; a large proportion of agricultural land has been degraded due to excessive disturbance, erosion, organic matter loss, salinization, acidification, or other processes that curtail productivity (Escarcha et al., 2018). Managing these soils involves increasing their physical quality while maintaining or improving the fertility. Practices that reclaim productivity and restore carbon storage include: nutrient amendments, applying organic substrates such as manures and composts and reducing tillage and retaining crop residues; conserving water (Accorsi et al., 2017). In agreement with previous scholars mulching and application of compost and organics manure controls soil erosion, organic matter loss and acidification.

Water harvesting and management technologies; as a strategy to secure water resources in rural areas, various types of rainwater management and harvesting system have been implemented, (British Columbia. 2020). This involves harnessing of rain or groundwater for agricultural or domestic use. Therefore, provision of supplementary water to croplands through irrigation and use of efficient irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns. Use of clean energy is important to avoid off-setting these gains through CO₂ emissions from the energy used to deliver the water or from N₂O emissions from higher moisture and fertilizer nitrogen inputs. There are several water-harvesting technologies: Zai pits,

retention ditches, road runoff harvesting, rock catchment harvesting, roof catchment harvesting, and construction of ponds, dams, and water pans, among others. To consider the adoption of the various water management and harvesting technologies, several social, cultural and economic factors should be considered such as peoples' priority and ability to use (Sharma & Ravindranath, 2019). The researcher agrees with the previous scholars because the practice water harvesting like water harvesting helps smallholder farmers to have adequate access to water supply even in times of drought. Such harvested water can be used for irrigation and drinking water for their animals.

Agro forestry; it is a set of land-use practices involving the deliberate combination of trees with agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence. There are lots of possible combinations of food products including crops and fruits, fodder, mulch/green manure and timber trees may, for example, be planted around homesteads (home garden), along fences, on the farm boundaries or on crop- or pasture land. The introduction of trees or shrubs creates a more diverse, productive and ecologically sound land use and environment. Social, economic and environmental benefits can for example be better food security, increased income and enhanced soil fertility (FAO, 2019).

In a country where the economy is heavily based on agriculture, development of the agricultural sector is the most efficient poverty reduction measure. Yet agricultural expansion for food production and economic development which comes at the expense of soil, water, biodiversity or forests, conflicts with other global and national goals, and often compromises production and development in the longer term (Sahman & Zhang (2018). However, apart from improving the people's wellbeing through increased incomes through provision of extra products such as

timber, firewood and fruits, agroforestry has potential to reduce vulnerability to climate change because it contributes to rain formation processes.

Drought tolerant crops; patterns of drought may need various sets of adaptive forms. Drought tolerance is the ability to which a plant maintains its biomass production during arid or drought conditions (WoOLF et al., 2018). Some plants are naturally adapted to dry conditions, surviving with protection mechanisms such as desiccation tolerance, detoxification, or repair of xylem embolism. Other plants, specifically crops like corn, wheat, and rice, have become increasingly tolerant to drought with new varieties created via genetic engineering (WoOLF et al., 2018). The mechanisms behind drought tolerance are complex and involve many pathways which allows plants to respond to specific sets of conditions at any given time. Drought tolerant crops require little water during growth because they reduce evapotranspiration during photosynthesis. (Yohannes et al., 2017). Tolerant breeds in livestock and poultry; local or indigenous breeds have the notion to forage for themselves (Teklewold et al., 2019). In nomadic systems, the animals show their owners when to move in search of new grasslands. Indigenous breeds have unique characters that are adapted to very specific eco-systems across the world. Such breeds have lower water intake requirements and thus optimize the use of water resources. These unique characters are resistant to droughts, thermoregulation, ability to walk long distances, fertility and mothering instincts, ability to ingest and digest low-quality feed, and resistance to diseases. These livestock breeds may not be highly productive in terms of meat or milk production, but are highly adaptive to the unpredictable nature and have low resource footprints (Mlenga & Maseko, 2015).

According to Liben et al., (2018) water-smart technologies like a furrow-irrigated raised bed, micro-irrigation, rainwater harvesting structure, drip irrigation, cover-crop method, greenhouse,

laser land levelling, reuse wastewater, deficit irrigation and drainage management can support farmers to decrease the effect of variations of climate. However, some of the water-smart technologies such as rain water harvesting structure (dam), drip irrigation according as listed by Liben et al., are costly to install in refugee settlements where people are constrained with finances.

2.6 Effect of climate resilient practices on the food security

Climate-resilient agriculture (CRA) prioritizes food security with a consideration of mitigating climate change (Ewbank et al., 2019; Kedir et al., 2021). According to Kedir et al., (2021) climate-resilient agriculture seeks to increase productivity in an environmentally and socially sustainable way, strengthen farmers' resilience to climate change, and reduce agriculture's contribution to climate change by reducing greenhouse gas emissions and increasing carbon storage on farmland.

Review of several studies (Aune, 2020; Assefa et al., 2019), on selected practices such as use of cover crops, rotation of crops, intercropping with legumes, water harvesting, irrigation, integrated nutrient management, contour farming, terracing, agroforestry, minimum tillage and crop residue management showed stability in production and significant increase in yield of crops both in the short and long run in humid and dry areas. The researcher agrees with the scholars by asserting that the increase in yield can be attributed soil management practices such as controlled soil erosion and improved soil structure.

Agroforestry system is one of the CRA practices that combine agricultural crop production including trees, forestry plants, and animal husbandry in the same unit of land in accordance with the culture of the local population for public welfare (Aune, 2020; Aleminew & Alemayehu,

2020). Planting trees improve the organic matter in the soil. As a result, soil fertility and soil moisture increase as well (FAO, 2017). Moreover, the presence of forests lessens the rate of small to moderate rain flows (FAO 2019). The water that falls to the ground is more controlled and does not erode the soil. Agroforestry is profitable because it allows farmers grow two or more different plants simultaneously in the same area. This system increases diversity, assures ecological balance, more utilization of natural resources, enhancement and sustainability in agricultural production (Adela et al., 2019). Although the scholars said that agro forestry improves food production, there are tree once they are planted with certain crops, crops dry up due to over competition for resources. For example, banana plantation with eucalyptus trees. Trees in this case outcompete the banana and banana ends drying up. Thus there was a need to establish which trees grow well with which crops.

Improved pasture and grazing management enhances the quality of forage, which in turn increases yield of livestock besides ensuring resilience to erratic weather patterns and effects of extreme weather events particularly in dry areas (Aune, 2020). A study conducted by Iscaro (2014) on the role of climate smart practices in combating climate change; desertification and improving livelihoods in Northern Nigeria indicated positive significance. However, there is need for appropriate institutions, political goodwill, adequate financial and human resources, besides availing information and incentives to enhance their adoption.

Adoption of climate-resilient agriculture practices such as agroforestry, integrated soil conservation management, water management systems, crop diversification are important adaptation strategies for smallholder farming systems in areas with high rainfall variability (Olawuyi, 2020). CRA strategies have been identified to play a key role in improving food systems through reducing food insecurity, addressing malnutrition, food misdistribution as well

as the relationship between agriculture and poverty in Ethiopia (Belay et al., 2017). However, the scholars did not disclose how each climate-resilient practice affects food production among smallholder farms. Hence, a justification for the current study.

The incorporation of trees and shrubs into the agricultural system helps to diversify and increase farm incomes and thus reduces the risks in agricultural production (FAO, 2019). Increases in tree and shrub cover can help to minimize the effects of extreme weather occurrences, such as heavy rains, droughts, windstorms and the effects of frost. These prevent soil erosion, stabilize soils, raise water infiltration rates, halt land degradation, enrich biodiversity in the landscape and increase ecosystem stability (FAO, 2019). Agroforestry is therefore important in helping farmers adapt to climate change by reducing their vulnerability to the effects of climate change, diversifying income sources and improving livelihoods.

According to Olayide and Kyle, (2017) conservation agriculture (CA) involves a combination of farming practices and tools that involve minimum soil disturbances, maintaining of permanent soil cover and diversification of plant species. It provides opportunities for improving food security through intensification of sustainable food production and contributing to climate change adaptation and mitigation. Conservation agriculture is ideal in the mixed farming of crops, livestock and agroforestry farming systems. Use of cover crops to suppress weeds in CRA practices helps to improve the agricultural efficiency by saving labour, time, effort and funds required for land cultivation. The saved resources can be reallocated to more profitable enterprises such as dairy farming. In broad terms, the benefits from CA can be categorized into environmental and economic benefits, but the ultimate gains are increased incomes, food security, adaptation and mitigation of climate change.

Mulching, where crop residuals are left to provide protective cover to the soil, helps suppress weeds, reduce loss of soil moisture through evaporation, keeps the soil cooler and thus protects crops from extreme temperatures, shields the soil surface from strong winds and rain and thus reduces soil erosion and the risks of flooding (FAO, 2017). The mulch facilitates rain water infiltration and the deeper rooting of crops. It also provides a substrate for soil inhabiting micro-organisms which helps to improve and maintain water and nutrients in the soil. They help to create soil structure with plenty of smaller pores through which rainwater can easily infiltrate the soil thus reducing surface runoff thus preventing soil erosion. As the mulch material decomposes, it increases the content of organic matter. This contributes to the net increase of soil organic matter derived from carbon dioxide captured by photosynthesis in plants, whose residues above and below the soil surface are subsequently transformed and sequestered by soil biota (Abera & Tesema, 2019). However, the contribution of mulching to climate change was not bought on board. Hence, justification for the current study.

Crop rotation is a mode of farming where a sequence is established in planting different types of crops on the same land, is another mode of conservation agriculture (Ho & Shimada, 2019) argued that crop rotation where a sequence is established in planting different types of crops on a given piece of land. It was integral to farming before the introduction of chemically intensive practices. In most cases, legumes (nitrogen-fixing crops) including trees and shrubs are planted after the harvesting of crops that do not fix nitrogen (Ho & Shimada, 2019). The legumes host nitrogen fixing bacteria in their root systems, therefore, they enrich the soil with nitrogen which is essential for plant growth. This cuts down the need for nitrogen-based fertilizers and thus reduces the GHG emissions induced by fertilizer production. Different types of crops take up different amounts of nutrients from the soil and thus crop rotation helps in soil nutrient

management. Crop rotation over several seasons helps to minimize the outbreak of pests and diseases and higher yields are just a few of the positive outcomes of the practice (ibid).

2.7 Factors limiting the adoption of climate resilient practices

The adoption of technologies has been shown to depend upon a myriad of factors including household and farm characteristics. These characteristics include age, gender, level of education, and head of household, asset endowment, farm size and farming experience. Other factors that influence decision with regard to adoption comprise perception of the problem, characteristics of technologies, institutions and the influence of the market (Ho & Shimada, 2019).

According to Harvey et al. (2018), the age of a farmer may positively or negatively influence the decision to adopt new technologies. Older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher likelihood of adopting the practice. On the other hand, older farmers are more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies (Jaramillo et al., 2013). Older farmers may find it hard to change the land use and diversify production on the farm. Their physical ability due to age may limit their abilities to undertake new CRA practices related to establishing farm business, movements towards new objectives and production intensity. However, the intensity of problems such as poor harvest they face may prompt them to adopt new technology if it promises to solve the problem so they can go out of it.

Limited access to financial services and incentives to adopt climate resilient practices Mbuli, et al., (2021). Adaptation and more sustainable agriculture involves changes in practices that can create costs and risks for farmers. Government subsidies are poorly targeted and normally focus

on reducing the costs of inputs without accounting for potentially negative spill-over effects. Government has a short supply of staff and financial resources to cover a wide geographic range and current services are often concentrated to accessible areas. Poor farmers also have limited access to credit/loan due to lack of collateral. Without financial support or incentives, farmers are unable to make the investments necessary to adopt climate resilient practices (Dinesh and Vermeulen (2016).

Weak market information, integration and infrastructure to support resilient farmer livelihoods. Farmers generally practice subsistence agriculture and face above-average risks from external shocks such as climate extremes and the underlying threat of poor harvests due to adverse growing conditions. Farmers have poor capacity to anticipate these risks and limited access to climate and market information that would help them anticipate and respond to near term climate risks (Ballard et al., 2018).

Education level is often assumed to increase the likelihood of embracing new technologies as it enhances the farmer's ability to recognize the effects of climate change (Dessie et al., 2019). Similarly, education enables households to access and conceptualize information relevant to making innovative decisions (Eshete et al., 2020). Educated households would easily adopt CRA practices because they make educated judgements and identify farm related opportunities for maximization were they exist. However, higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production. Again position of a family member may affect as according to African tradition as the husbands/fathers ideas and needs dominate actions in the family or households.

The effect of gender of household head on adoption decisions is location-specific culture driven (Kebede et al., 2019). In many parts of Africa, women are often deprived of property rights due

to social barriers (Mengistie & Kidane, 2016). Consequently, they have fewer capabilities and resources than men (Teklewold et al., 2019). However, female-headed households are more likely to take up climate change adaptation measures (ibid). The possible reason for this observation is that in most rural smallholder farming communities in Africa, more women than men live in rural areas where much of the agricultural work is done. Therefore, women have more farming experience and information on various management practices and how to change them, based on available information on climatic conditions and other factors such as markets and food needs of the households (Mlenga & Maseko, 2015).

The influence of household size on the decision to adopt new farming techniques in response to climate change is uncertain. Household size as a proxy to labour availability may influence the adoption of a new technology positively as its availability reduces the labour constraints (FAO & UNDP, 2018). Given that the bulk of labour for most farm operations in Sub-Saharan Africa is provided by the family rather than hired, lack of adequate family labour accompanied by inability to hire labour can seriously constrain adoption of these practices (Rugege et al., 2017). Nonetheless, households with many family members may be forced to divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption burden imposed by larger household size.

Size of the farm. Land statistically and positively affects the degree of adoption of CRA. Farmers with larger farm lands adopt more CRA practices, Rugege et al., (2017) argued that land fragmentations may be a barrier to CRA implementation. Land is a vital resource in agricultural output and households with access to enough farmland and other resources won't be able to host the practices required to achieve a fruitful agriculture.

Distance to the farmland. Farmers who cultivate distant from their homesteads are more less likely to use CRA practices. This is due to the difficulties they have in practicing good and effective management due to the stress presented by distances as compared to their peers who live adjacent to their farms. Apart from affecting market accessibility (Teklewold et al., 2019), distances can also affect important aspects of agriculture such as access to technology, knowledge and financial institutions.

According to Velmurugan et al. (2016), institutional factors could also influence adoption of new technologies and they include; access to credit, access to information, off-farm employment, land ownership, group membership and government policies. Adoption of new farming strategies require funds and lack of borrowing capacity may limit ability of farmers to embrace adaptation measures that require heavy investment for instance in strategies such as irrigation, terracing, tree planting, soil testing and fertilizer use (Snilstveit et al., 2019). Access to information may influence farmers' decision to adopt new technologies as they were made aware about its existence (Sloat et al., 2020).

Land ownership has an implication on the property rights and long term investment in climate change adaptation strategies. For instance, tenure security can contribute to adoption of technologies linked to land such as irrigation equipment or soil conservation practices. Farmers lack economic incentives to invest their time or money if they cannot capture the full benefits of their investments (Snilstveit et al., 2019; Wezel et al. 2014).

Institutions also play a critical role in adoption of agricultural practices (Escarcha et al., 2018). British Columbia (2020) affirms that effective adoption of climate smart practices requires involvement of institutions at all levels. For instance, local collective and civil society institutions play a significant role in terms of asset building, access to information, resource

mobilization, capacity and skills development, creating linkages necessary for adoption of adaptive strategies. The policy context that supports payments for environmental services, funds research and promotes dissemination of information and advice also greatly influences the adoption of new practices (Mengistie & Kidane, 2016).

Knowledge of CRA practices; knowledge is organized information or data, and is considered crucial in the process of adoption of innovations (Mlenga & Maseko, 2015). Liben et al. (2018), asserts the importance of knowledge in influencing the decisions and actions of farmers in the course of adopting technologies or practices and goes further to characterize and categorize knowledge into three: knowledge on awareness, how to adopt and underlying principles of adoption.

Anderegg et al. (2019), indicated that perceptions of adopters significantly influence adoption decisions. The adopter perception paradigm postulates that the process of adoption starts with the adopter's "perception of the problem and technology proposed" (FAO, 2017; Jones & Tanner, 2016). Abera & Tesema (2019) also contends that perceptions about the environment influences adoption of strategies for adaptation to climate change. Ho & Shimada (2019) further affirms that decisions and actions with regard to development and adoption of adaptation strategies to climate change are informed by perception of the climate risk among other factors.

2.8 Options of/strategies for climate resilient practices that can enhance food security

Chandra & McNamara (2018) asserted that awareness creation among farmers increase successfulness of CRA. Thus availability of extension services is essential in scaling up CRA. External support especially by imparting more awareness and supplementing the communities with coping technologies has been clearly emphasized. Climate smart agriculture initiatives are therefore of paramount importance. Nongovernmental organizations are likely to play an

increasingly important role in building awareness and delivering appropriate technologies to farmers. The awareness of the farming community on the impacts of climate change and their ability to adapt needs to be supported (Belay et al., 2017).

According to Bernier et al. (2015), one of the solution for farmers to enhance production under harsh climatic conditions is to conserve whatever rainfall they receive through mulching, digging trenches to hold water, pruning, forking and planting shade trees. Agronomic practices that conserve moisture are needed before there can be any talk about new technologies or new varieties that are drought tolerant.

Intercropping crops with shade trees has been perceived as an efficient approach to adapt climate change and achieve sustainable food crop production socially, environmentally and economically (Herlina & Prasetyorini, 2020). In fact, in certain parts of the world, food crops are grown in shaded agroforestry systems and shade trees are now frequently found in crop systems where temperature and rainfall are not favorable. In Uganda for example, majority of coffee fields are covered by shade trees with diverse shading intensity. Coffee can benefit from shade trees in diversified aspects. Shading contributes to modifying the microclimate so that the extreme climate conditions such as extremely high or low temperature are reduced.

Farmers require knowledge and information on the appropriate CRA practices, technologies to effectively adapt to changing climatic conditions and cope with climate variability. As reported by Abera & Tesema (2019) trainings on the innovative climate-smart agricultural has equipped smallholder farmers with the skills and techniques to make their agricultural activities part of the solution to the negative impacts of climate change.

According to Abera & Tesema (2019) there is need to develop labour saving practices such as use of weedicides, improved tools for planting and harvesting to cut down the major cost on labour. Efforts should also be made to boost the export trade by enhancing its production volume.

According to Ademola et al. (2016), effective engagement in the market by farmers is also considered as key factor that determines farmers ability to adopt technological practices. Ho & Shimada (2019) asserts that existence and engagement of markets by small scale farmers enhances their livelihood strategies. Other factors that have been shown to influence adoption of new practices include market imperfections (Maitra et al., 2019). Surveys have also shown that where the tools for implementation are readily available and accessible in the local marketplace, adoption of technologies becomes easier (Ademola et al., 2016).

Jones & Tanner (2016) stated that investing in climate resilient agriculture can only succeed if people understand the reasons why these investments are made, and what type of threats they are facing. Education, information and knowledge sharing can contribute to communication and thereby community involvement. Traditional and local knowledge, also known as Indigenous Technical Knowledge (Herlina & Prasetyorini, 2020) of farmers and resource users is vital in building more understanding of agriculture and the environment (FAO, IFAD & UNICEF, 2020). Awareness that climate change is an issue well established and investment strategies need to be put in place. According to Jones & Tanner (2016), practical guidance should go beyond creating awareness. FAO (2017), assert that awareness raising on smart climate needs to be enhanced through farmer facilitations through radios and TVs.

Increasing farmers awareness of the consequences of climate change. Farmers who believe that climate change has a negative effect on agricultural production would adopt more of CRA

practices. This is associated with the findings of Ademola et al., (2016), farmers who observed a rise in floods and decline in moisture levels in their area were more likely to implement more CRA practices. Farmers recognize the threat and challenges posed by climate change and tend to recognize the purpose of CRA practices in improving their resistance to climate change impacts. A significant degree of knowledge of climate change negative impacts on food production among the people would prospectively boost CRA adoption in the area.

Assets and wealth endowment such as income, savings and access to credit, and insurance is considered to have significant influence on adoption of technologies by small scale farmers. This is because they act as a ‘safety net’ in time of crisis, enabling farmers to innovate, and take risks, which support long-term sustainable adaptation (Abera & Tesema, 2019). Similarly, technology adoption in some cases requires heavy capital investment, which in most cases is out of reach to majority of the rural farmers. This implies that farmers with higher resource endowments are more likely to adopt climate smart practices compared to the less endowed farmers (Herlina & Prasetyorini, 2020). This serves as a “buffer” in times of need, which makes it less risky to invest in alternative livelihoods (FAO, 2018).

FAO (2019) points out that, secure access to land, livestock and water resources are essential for investments in climate resilient agriculture as they represent the foundation for rain fed subsistence agriculture. Access to land and water is not a given fact, especially in Africa where the land is communally owned. Secured access to land for smallholder farmers is problematic as they do not have secure rights to land accessibility. Lack of secure access to land and water could constrain efforts to invest in agriculture (ibid).

2.9 Summary of literature review

From the review of literature studies on climate smart, there have been various practices such as conservation agriculture; water management, agroforestry that exists. However, adoption of many CRA practices has been very slow, particularly in food insecure and vulnerable regions in sub-Saharan Africa and Southeast Asia especially among smallholder farmers. There are several potential explanations for failure to adopt such activities which in the above literature they have not been addressed (Giller et al., 2009). Due to dynamic and the uncertain nature of climate change impacts, capacity development approach that is comprehensive and which stimulates socio-institutional learning processes and at the same time utilizes the innovation potential of agricultural systems is required to transition towards climate-resilient agriculture. Bridging the current information and knowledge gap for more inclusive and effective decision-making within CRA is a key challenge. Successful adaptation to climate change by small producers is not merely a question of developing new adaptation technologies but depends on ensuring access and use of them.

The literature presented above rotates on the possible effect of climate change on agricultural production and ways of adapting to climate change (Adams et al., 1998; IPCC, 2007; Boruru, et al., 2011; Okumu (2013). These studies generally indicate that farmers can overcome the adverse impact of climate change by implementing adaptation measures. Much of the literature review on agricultural adaptation to climate change has drawn attention to a range of factors affecting the adoption of such methods by small-scale farmers. A lot of these studies merely identify household, farm characteristics and institutional factors as the key determinants of adoption (Adesina & Forson, 1995). However, there is a dearth of information on the drivers of choice and impact of specific CRA practices on household food security status of small scale farmers in

refugee settlements. The scoping of these studies were generally done at the national level targeting major stakeholders in agricultural sector (FICCF, 2014). The study was done to determine the effect of CRA practices on household food security status and provided recommendations on the most appropriate practice that would enhance household food security amidst climate change.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Area of study

The study was carried out in Oruchinga refugee settlement in Isingiro District, South Western Uganda. The settlement was started in 1959 as a transit camp for refugees of Rwandese origin who were affected by tribal clashes in Rwanda. By the time of the study, the settlement had over 8000 refugees from Burundi, DRC and Rwanda. Agriculture was the main economic activity in the area with emphasis on food crops like; sweet potatoes, beans, cassava, maize, bananas, groundnuts, onions and cabbage.

The average rainfall received in the area was about 1000 mm per annum. There are two rainfall regimes, the first season begins in March to May and the other in August to November. These were punctuated by two dry spells in June to July and between December and February. The area experienced mean annual maximum temperature of 20⁰C and mean annual minimum temperature of 14.5⁰C. High temperatures have been recorded in the months of January-March and July-September which are months that correspond to dry spells. CRA were promoted to improve the food security situation of the households amidst the harsh climatic conditions. The choice of the area was because it had a witnessed continuous food shortages resulting from low agriculture sector performance caused by alternations in temperature and rainfall (UNHCR, 2014).

3.2 Research design

This study adopted a descriptive research design involving both qualitative and quantitative approaches. The qualitative approach collected data on the effect of climate resilient agricultural practices on food security among households in Oruchinga refugee settlement. This approach was subjected to key informants. Quantitative approach was also used to collect data about in

climate resilient agricultural practices and food security. This approach was subjected to farmers. The descriptive research design was unobtrusive not to affect the results of the study. Thus, the design used to gather quantifiable responses from respondents using questionnaires and interviews.

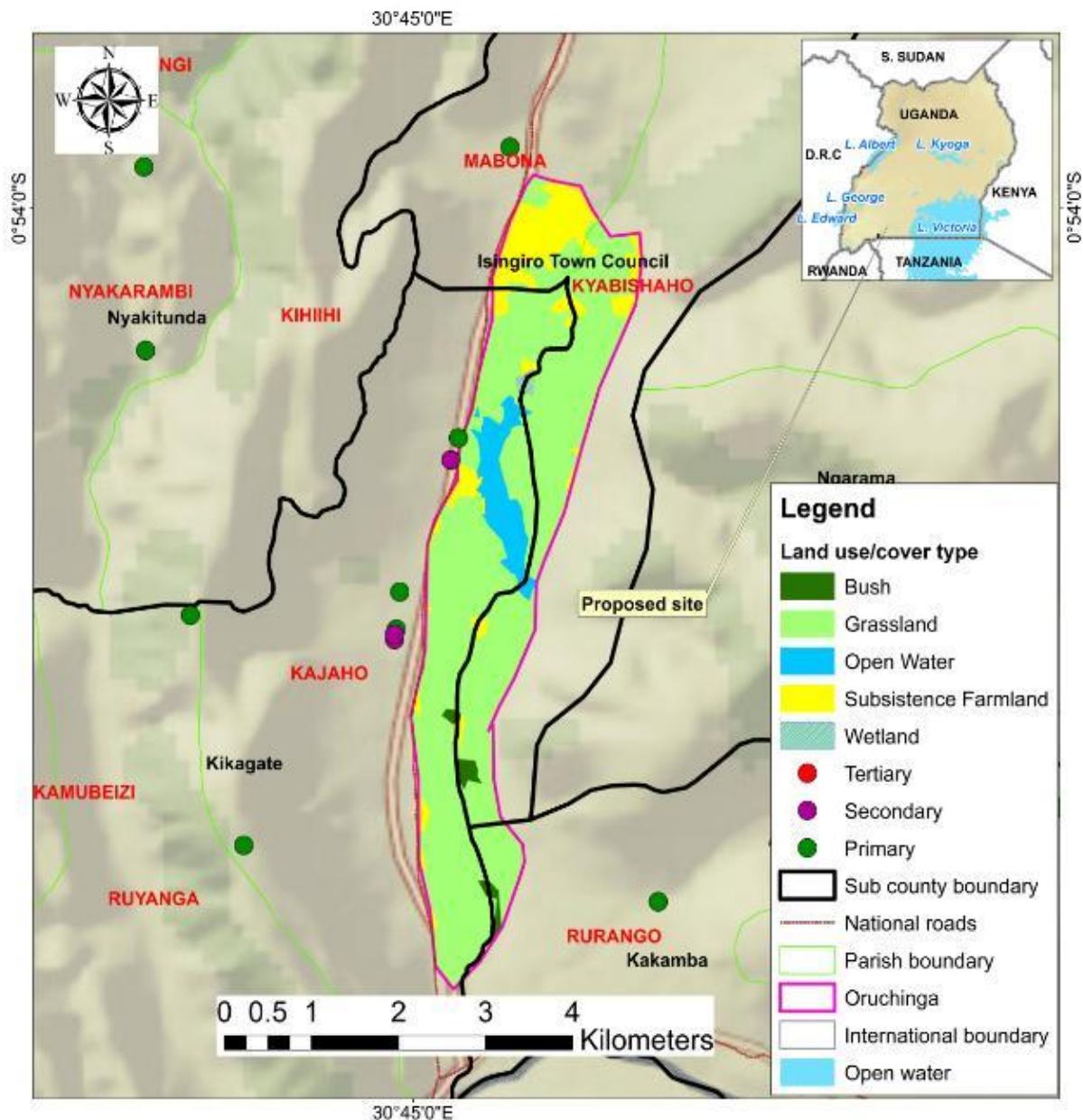


Figure 3.1: A map of Oruchinga refugee settlement in Isingiro District

3.3 Study population

The study targeted farmers practicing different agricultural enterprises and key informants like extension service providers and political leaders. The settlement hosts more than 8000 refugees from Burundi, DRC and Rwanda. An estimated 30% (2400 farmers) of the population was involved in different agriculture related ventures and activities. Farmers were considered for their role in production, harvest management and marketing. Agricultural extension workers were considered for their technical knowledge, advisory services and policy implementation.

3.4 Sample Size determination

The sample size comprised of 322 respondents. The sample size was determined using a formula by Kish (1965). According to the formula, the sample size was determined with some degree of precision of the general population used. In this case the sample was determined as follows;

$$n = p \times q \times \frac{(Z_{\alpha/2})^2}{e}$$

$$n = \frac{Z_{\alpha/2}^2 \times (p) \times (1-p)}{e^2}$$

Where:

n = Sample size

p = population involved in different agricultural enterprises = 30% = 0.3

q = young population and those involved in other ventures = 70% = 0.7

e = standard error = 5% = 0.05

$Z_{\alpha/2}$ = Z value of 95% confidence = 1.96 from the Z-table

Substituting the values into the formula: $n = 0.3 \times 0.7 \times \frac{(1.96)^2}{0.0025} = 322 \text{ respondents}$

0.0025

The total number of agricultural extension workers working in the settlement was 14 (UNHCR, 2014). And due to the fact this was small number, decided to consider all so as to obtain adequate data to back up the data collected from farmers as presented in table 3.1.

Table 3.1: Sample size and Sampling procedure

Category	Target population	Sample size	Sampling procedure
Farmers	2400	322	Simple random sampling
Extension workers	14	14	Purposive sampling
Total	2414	336	

3.5 Sampling techniques

The study employed both simple random and purposive sampling techniques to select respondents.

3.5.1 Simple random sampling

The researcher used simple random sampling to select farmers. This was achieved by getting a list of farmers from each enterprise with the help of area extension service provider on the day of data collection. Each farmers' name was assigned a random number and it was from the random numbers that the researcher selected the required number of respondents (322). Simple random sampling method was used so as to give all the members of study population equal and independent chances of participating in the study and it saved time and costs.

3.5.2 Purposive sampling

Purposive sampling was used in the selection of agricultural extension workers. The list of agricultural extension workers was obtained from the Regional Refugee Office-Mbarara. This technique helped in gathering data from extension workers because of the much more knowledge

about the phenomenon that was being studied. Agricultural extension workers in this case provide supplementary information that was not provided by other respondents.

3.6 Data Types and Sources

Farmers and agricultural extension workers provided primary whereas secondary data was collected by reviewing documented literature and other potential sources like online books, journals, research papers and internet were used.

3.7 Data collection methods

This study used survey guided by questionnaire and interviews guided by interview guide as methods of data collection.

3.7.1 Survey guided by questionnaire method

A semi-structured questionnaire was designed and used to collect data from farmers. The questionnaire comprised of both closed ended and open ended questions which were designed to generate quantifiable information from the farmers. The questions were designed in English and later translated into local languages and this made the questions simpler, clear and understandable to the farmers/respondents. This achieved by the help of settlement language translator. The self-administered questionnaires were used were given to the selected farmers to answer questions related to the study phenomenon. This increased response rate.

3.7.2 Interview method

This method was used to gather information from agricultural extension workers. The researcher conducted interviews guided by interview guide reflecting the study objectives. With this method, the researcher engaged agricultural extension workers in oral questions which was used to supplement and extend researchers' knowledge about individual (s) thoughts and behaviors.

While interviewing, probing was applied in cases where respondents did not give adequate answers or where respondents got confused of the meanings.

3.8 Data collection tools

3.8.1 Questionnaire

A self-administered questionnaire with both open and closed ended questions was used to generate data from the farmers. Given the nature of the study, the study questions covered a wide range of information including respondent characteristics and other parts were developed basing on study objectives. For example, the self-administered questionnaire was used to gather information on;

- Socio demographic characteristics like sex, age, education level, occupation, household income, household size, farm size, access to markets, access to credit and access to extension services.
- food security situation among households
- Climate resilient agricultural practices adopted within the settlement camp.
- Effect of CRA practices on the food production systems
- Potential factors limiting the adoption of climate resilient agricultural practices.
- Available adaptation possibilities that can aid craft resilience to climate change and variability for smallholder farmers in the settlement.

3.8.2 Interview Guide

The interview guide was a piece of paper with logically following questions about the study phenomenon. It was designed in a logical way so as to keep track of responses obtained from different respondents. This tool was subjected to agricultural extension workers.

3.9 Data Quality Control

3.9.1 Validity of Instruments

Validity occurs when the data measures what it ought to measure. Validity shows that the study tool is assessing what it ought to (Tabachnick & Fidell, 2007). Validity signifies the extent to which the inferences acquired from the examination of facts and figures in point of fact symbolize the scenario under investigation. The questionnaire was pre-tested to make sure it was not defective and that the respondents comprehended it by discussing with 10 random respondents outside the target sample. The observations from the discussions were assessed and worked on to enrich content validity of the instrument.

3.9.2 Reliability of instruments

Reliability is the consistency of measurement, or the level to which a study tool measures in a similar manner every time it is utilized in the same situation with the same elements (Tabachnick & Fidell, 2007). The researcher adopted the Cronbach's Alpha (α) to test reliability. Ten questionnaires were given to random participants then examined by means of SPSS version 21 software to check for the Alpha level. The reliability cut off conventional value of 0.7 was adopted. The Cronbach's Alpha from the instruments was 0.811 which was higher than the reliability cut off conventional value of 0.7. This finding indicated that the questionnaires were reliable and therefore ready to be used in the study as they attained the minimum required conventional value.

3.10 Data management and Analysis

3.10.1 Data management

The data collected was cleaned, edited and coded to avoid incompleteness during entry. Minor mistakes committed during data collection were corrected. Upon the completion of data

collection and editing in the field, systematic organization of raw data was done to facilitate data analysis.

3.10.2 Data analysis

Data was analyzed under two major principles that was quantitative and qualitative analysis.

3.10.2.1 Qualitative data analysis

Qualitative data was analyzed thematically by developing themes that reflected the study objectives. The recorded information was transcribed verbatim. Observational field notes were incorporated into data for analysis. The transcripts were read repeatedly and words with similar meanings grouped into categories. Similar categories were grouped into themes and subthemes to avoid repetitive information and they were presented as results. All these were done with the help of Microsoft Office Excel 2016.

3.10.2.2 Quantitative data analysis

The collected data was subjected to the relevant data cleaning, processing and analysis. Data processing and analysis was facilitated by the use of the Statistical Package for Social Sciences (SPSS) Version 21 software. Data analysis encompassed both descriptive statistics and inferential statistics. Descriptive statistical tools which included frequencies, means, mode, standard deviations, and variance were used. On the other hand, inferential statistics were in form of binary logistic regression analysis. The results of the analysis were presented in form of tables. Both descriptive and inferential statistics aided in the interpretation of findings.

Objectives one

Objective one involved assessment of different climate resilient agricultural practices adopted by small holder farmers. The quantifiable information gathered was analyzed using descriptive

statistics to generate average mean for continuous variables, as well as frequency counts and percentages for categorical variables. Thematic analysis was also performed on data gathered through interviews.

Objective two

Objective two involved identification of the potential factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement. Since the dependent variable was dichotomous in nature (1=for the adopters of the CRA practices, 0= for non-adopters), a binary logistic regression was used to predict the relations between the dependent and independent variables. The model was preferred for this objective because it was most appropriate in predicting the chances of an event happening. The model was expressed as;

$$\log(p / 1 - p) = \alpha + b_1x_1 + b_2x_2 + b_3x_3 + \dots + b_nx_n + e \dots \dots 3.2$$

Where; p = the probability of adopting climate resilient agricultural practices

α = the coefficient on the constant term

$b_1 \dots b_3$ = the coefficient(s) on the independent variable(s)

$X_1 \dots X_2$ = the independent variable (such as; labour, land, capital, education level, experience, access to credit, technology, age, sex, access to information, engagement in off farm activities, membership in farmer group).

Objective three

Objective three was involved determination of the effect of specific climate resilient agricultural practices on the food production systems of smallholder farmers in refugee settlement. Multivariate analysis using linear regression model was performed to assess the possible

association between independent variables and dependent variables. The regression model was expressed as;

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 = \dots\dots\dots 3.2$$

Where: α = represents the constant

$\beta_1, \dots, \beta_2$ = Regression coefficients

$X_1, \dots, X_3$ = independent variables

Objective four

Objective four involved identification of the strategies for climate resilient practices that could enhance food security in the settlement camp. Responses gathered on this objective were analyzed using descriptive statistics to frequency counts and percentages. Thematic analysis, review of documents and online publications were used to supplement the quantifiable findings.

3.11 Study limitations

Given the nature of the study, the researcher encountered numerous setbacks as highlighted below;

A major setback of the study was failure to get enough local research findings relating to the study phenomena. This problem was however solved by the researcher downloading and reviewing published documents/journals online.

Some respondents could try to respond to some questions saying that the information required was regarded as sensitive and confidential to some respondents. This however was solved by assuring respondents that information given was for academic purposes and was treated with utmost confidentiality.

3.12 Ethical Considerations

Ethical approval for the study was obtained from the Research and Ethics Committee of Bishop Stuart University. Further approval was obtained from the administrators of the Oruchinga settlement camp and finally a written informed consent was obtained from each of the participants after giving a description of the study before actual data collection. Participants were guaranteed confidentiality of the information they were to provide. This was preceded by thorough explanation of the aim and objectives of the study. Participation was based on informed and voluntary consent. Respondents for the study were informed of their right to withdraw from the study at any time they saw necessary. Respondents were fully assured of their confidentiality and anonymity. Confidentiality of data was maintained by use of identification numbers rather than names and limiting access to the data. Throughout the field work, ethical consideration was emphasized.

CHAPTER FOUR: RESEARCH FINDINGS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the research findings, their presentation and interpretation. The study was particularly interested in an assessment of the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District. Questionnaires were handed out to three hundred twenty-two (322) respondents who were requested to return them by 31st March, 2023. All the three hundred twenty-two questionnaires were returned which represented a response rate of 100%.

4.2 Socio-economic characteristics of farmers

This sub-section presents the demographic features of 322 sampled respondents. The key demographic characteristics captured for the study included; gender, age in years, marital status, and education level. These features were found to be of great help in terms of clearly depicting the diverse background of farmers.

Table 4.1: Bio-demographic characteristics of the households

Household Characteristics		Total (n=322)
Sex of respondents (%)	Female	206 (63.9%)
	Male	116 (36.1%)
Age of respondents (%)	24 and below	52 (16.2%)
	25-50 years	241 (74.8%)
	51 and above years	29 (09%)
Marital status (%)	Single	83 (25.7%)
	Married	226 (70.3%)
	Others	13 (4.3%)
Education level (%)	None	43 (13.3%)
	Primary	60 (18.6%)
	Secondary	124 (38.5%)
	University	95 (29.5%)

4.2.1 Gender of the respondents

Respondents were asked their sex and their responses were recorded in table 4.1 above. This gave a clear picture on the number of men and women directly involved in the agricultural sector. The study was relatively dominated by females (63.9%) compared to males (36.1%). The dominance of women in the agricultural sector can be attributed to a combination of social, economic, and cultural factors. For example, traditional gender roles have assigned women the responsibility of working on the land and managing household agriculture. These roles are deeply rooted in Ugandan culture and have been passed down through generations. Moreover, women also had limited access to formal education compared to men which limited their opportunities in non-agricultural sectors and made agriculture a more accessible avenue for employment and income generation.

4.2.2 Age of respondents

The researcher needed to know the age distribution of respondents to help categorize them. Respondent's age was also necessary because it is an influential factor in access and ownership of production resources. It influences production decisions, agricultural information seeking behavior and capacity to access credit services. Results in the table 4.1 above indicated that the study was dominated people aged 25 to 50 years with 74.8%, followed by those who were aged 24 years and below with 16.2% and small number of respondents were above 51 years. This implies that there was a fair age distribution from the young to the old. Majority of the respondent's surveyed across were aged 25 - 50 which is a vibrant productive group justifying their active involvement in agricultural production activities to sustain their livelihoods.

4.2.3 Marital status of the respondents

Marital status of respondents was considered because it is very critical in decision making, adoption of production technologies and other management practices. More than a half (70.3%) of the respondents were married, 25.7% were unmarried while were widowed and separated respectively. The dominance of the married in agricultural activities is explained by the fact that they involve more in agriculture to generate enough food and incomes to sustain their families. It is also a reflection of stability of family and the society at large which makes them engage in agriculture.

4.2.4 Level of education

Education level of the respondents was considered because it is very critical in technological adoption and use, production decision making and information seeking behavior of urban farmers. Respondents held a range of educational qualifications from primary to master level. Majority (38.5%) of the respondents had secondary education, 29.5% university education, 18.6% primary while 13.3% had no formal education. The projection of the results further shows that the agriculture sector of the area has attracted the highly educated members of the community. Most farmers presented relative levels of education and hence were capable of involving and increasing productivity through quick understanding of trainings and demonstrations given on to them. Having educated farmers can bring about a range of benefits to the agricultural sector and the broader economy. Education equips farmers with knowledge and skills that enable them to make informed decisions, adopt modern practices, and improve their overall productivity and livelihoods.

Table 4.2: *Household socio-economic background*

Household Characteristics		Total (n=322)
Family size (mean $\pm$ Std. D)		4.49 $\pm$ 1.322 members
Size of the land in acres (mean $\pm$ Std. D)		2.67 $\pm$.757 acres
Land ownership (%)	Own the land	219 (68%)
	Hired and paid	96 (29.8%)
	Given by government	07 (2.2%)
Type of labour used on the farm (%)	Family	186 (57.8%)
	Hired	136 (42.2%)
Type of farming practiced (%)	Commercial farming	89 (27.6%)
	Subsistence farming	156 (48.4%)
	Both	77 (23.9%)
Agricultural enterprises on the farm (%)	Crop enterprises	211 (65.5%)
	Animal enterprises	46 (14.3%)
	Both	65 (20.2%)

Respondents were asked to describe their household socio-economic background and their responses were recorded in table 4.2. On average, most household size constituted of 4.49 $\pm$ 1.322 members. Household size played a significant role in the agricultural sector for several reasons, as it affected the labour force available for farming, resource allocation, decision-making, and overall productivity. Most households were found to have relative labour available for agricultural activities. This was beneficial in tasks such as planting, weeding, harvesting, and post-harvest handling. The impact of household size on the agricultural varied based on cultural norms, economic conditions, technological advancements, and other contextual factors. However, the efficiency of labour utilization depended on factors like age, health, and skill levels of household members.

Average size of land were 2.67 acres. Land size was a critical factor that significantly influenced agricultural production. Land available to farmers determined the scale of their operations, their

ability to implement various climate resilient agricultural practices, and the overall productivity. Land size was found to directly affect the scale of agricultural production where by larger land holdings provided more space for cultivating crops and raising livestock, allowing farmers to produce larger quantities of agricultural products.

More than a half (68%) of the respondents owned land, 29.8% used hired or paid land while 2.2% were given land by government. Owning land, renting or hiring land, and receiving land from the government each were found to have their own set of benefits and considerations. The choice between these options depended on various factors, including individual goals, financial resources, tenure security, and long-term plans. The dominance of those who owned land is justified by many farmers who wanted land security and control, quick decision-Making and long term planning.

More a half (57.8%) of the respondents used family labour on the farm while 42.2% used hired labour. Using family labour in agriculture has several benefits compared to hiring external or hired labour. The choice between family labour and hired labour depended on factors such as the size of the farm, the scale of production, the skills and availability of family members, and economic considerations. Moreover, farmers reported that family was flexible and cost effective as well as promoted commitment and dedication where family members are often more committed and dedicated to the success of the farm since they have a vested interest in its well-being.

Majority (48.4%) of the respondents practiced subsistence farming, 27.6% commercial farming while 23.9% practiced both substance and commercial agriculture. The dominance of subsistence form of farming in the area was depicted on a combination of historical, economic, social, and environmental factors. As a result of small sized land found in the area, many households

produce crops and raise animals primarily for the family's consumption rather than for commercial sale. Subsistence farming has been a traditional way of life in the community for generations. Farming practices and land management techniques have been passed down through families, contributing to the continuation of subsistence agriculture.

Lastly, most (65.5%) of the respondents owned crop enterprises, 14.3% animal enterprises whereas 20.2% had a mixture of both crop and animal. The dominance of crop enterprises was attributed to the small sized nature of land owned by majority of the households. These small sized land only favored crop production compared to specific livestock projects which require huge pieces of land.

4.3 Climate resilient agricultural practices used by smallholder farmers within the settlement camp

This section of the study addresses research objective one which sought to establish the different climate resilient agricultural practices used by smallholder farmers within the settlement camp. Data gathered on this particular objective was analyzed on Univariate level using frequency counts and percentages as presented in table 4.3 below.

Table 4.3: Climate resilient agricultural practices used by smallholder farmers within the settlement camp

Climate-resilient agricultural practices	Total (n=322)
Agroforestry	67 (20.8%)
Use of improved crop varieties	45 (13.9%)
Improved livestock breeds	44 (13.7%)
Water-smart technologies	53 (16.5%)
Soil fertility management	34 (10.6%)
Use of compost and organic pesticides	59 (18.3%)
Small scale irrigation	20 (6.2%)

Results of the climate resilient agricultural practices used by smallholder farmers within the settlement camp were presented in table 4.3 above. Majority (20.8%) mentioned agro-forestry, 18.3% use of compost and organic pesticides, 16.5% water-smart technologies, 13.9% use of improved crop varieties, 13.7% improved livestock breeds whereas 10.6% and 6.2% reported soil fertility management and small scale irrigation respectively. The projected findings indicate that there are various climate resilient agricultural practices adopted by smallholder farmers although agroforestry, the use of compost and organic manures, and water-smart technologies were the widely adopted practices among smallholder farmers due to their effectiveness in addressing the challenges posed by climate change and variability. These practices offered various benefits that enhance agricultural productivity, resource sustainability, and resilience in the face of changing environmental conditions. The adoption of these practices aligned with the need for climate resilience in the settlement, where changing rainfall patterns, increased temperatures, and other climate-related challenges impact smallholder farming communities. These practices not only enhance agricultural productivity and income but also contribute to the long-term sustainability of rural livelihoods and ecosystems.

4.4 Effect of climate resilient agricultural practices on the food production systems of the local's in the camp

This section addresses research objective two which sought to determine the effect of selected climate resilient agricultural practices on the food production systems of the local's in the camp. The association between selected climate resilient agricultural practices and food production were determined at multivariate level. Regression analysis was conducted to test whether CRA practices significantly affected household food production/security in the camp as summarized in Tables 4.4 and 4.5 respectively.

Table 4.4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.925a	.856	.803	.547
a. Predictors: (Constant), Climate resilient agricultural practices				

To explain the percentage of variation in the dependent variable (household food production/security), the researcher used coefficient of determination obtained from the model summary in table 4.4 above. From the analysis, the value of $R^2 = .856$ suggests that 85.6% of household food production/security was explained by CRA practices such as agro-forestry, tolerant crops and animals, water-smart technologies, soil fertility management, organic manure application and small scale irrigation. The remaining 14.4% was explained by other practices not examined in this particular study. The higher R^2 value also implies a high strength of the linear relationship between the independent variable (CRA practices) and the dependent variable (household food production/security). To ascertain the relative strength of the predictor variables have on food production/security among households in the, multiple regression analysis was conducted. The results are presented in Table 4.5 below.

Table 4.5: Regression coefficients for household food production/security in relation to CRA practices

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	6.379	.401		15.912	.000
Agro forestry	.500	.063	.320	7.993	.000
Use of improved crop varieties	.305	.026	.421	11.869	.000
Use of improved livestock breeds	.274	.038	.284	7.138	.230
Water-smart technologies	.367	.185	.348	1.984	.012
Soil fertility management	.271	.080	.491	3.386	.010
Compost and organic pesticides	.211	.081	.425	2.584	.032
Small scale irrigation	.021	.681	.045	.203	.263
a. Dependent Variable: Food production					

As shown in table 4.5 above, a simple regression analysis was conducted to determine the effect of CRA practices on household food production/security. The analysis was undertaken at 95% confidence interval and 5% significance level. The coefficients explain the changes in the probabilities of the outcome as a result of a unit change in the explanatory variables. Agro forestry was the strongest predictor of household food production/security ($\beta = 0.500$), followed by water-smart technologies ($\beta = 0.367$), use of improved crop varieties ($\beta = 0.305$), soil fertility management ($\beta = 0.271$) and use of compost and organic pesticides ($\beta = 0.211$). For instance, a unit change in agro-forestry systems were found to affect household food production/security by 0.500. Water-smart technologies were also found to influence household food production/security by 0.367. This further applied on use of improved crop varieties where a unit increment affected household food production/security by 0.305. A unit application of soil fertility management practices increased household food production/security by 0.271. A unit increment in the use of compost and organic pesticides increased household food production/security by 0.211. The combination of agroforestry, improved crop varieties, soil fertility management, and the use of compost and organic manure was found to have synergistic effects on household food production and food security. When these practices are integrated, they create a holistic approach that maximizes agricultural productivity and sustainability. For example, Agroforestry systems introduced a variety of trees, crops, and sometimes livestock. This diversity led to increased yields, reduced risks from pest and disease outbreaks, and improved resilience to climate variability. Moreover, planting improved crop varieties that were well-adapted to the local conditions and had higher yield potential contributed to higher productivity.

4.5 Potential factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement

This section addresses research objective three which sought to establish the factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement. This objective was analyzed using bivariate and multivariate levels of analysis as presented in tables 4.6 and 4.7 below;

4.5.1 Bivariate analysis between adoption of climate resilient agricultural practices and associated factors

At bivariate level of analysis, significant associations between independent and dependent variable were assessed and analyzed using Pearson correlation at 5% level of probability as in table 4.6 below;

Table 4.6: Association between adoption of CRA practices and associated factors

Factors	Adoption of CRA practices	
	Chi-Square	Sig.
Age	.567	.018
Level of education	.044	.833
Family size (labour)	.812	.001
Experience in farming	.766	.096
Land size	.487	.022
Gender	.446	.035
Marital status	.790	.285
Religion affiliation	.624	.002
Income status	.493	.174
Knowledge on CRA practices	.732	.004
Membership in farmer group	.793	.002
Access to credit	.855	.000
Reoccurrence of pests and diseases	.174	.068

Results of the association between adoption of climate resilient agricultural practices and associated factors were presented in table 4.6. Adoption of CRA practices was used as the dependent variable and different socio-economic characteristics of farmers as the independent variable. At bivariate level, adoption of CRA practices had a moderate association with age ($\chi^2 = .567$, $p = 0.018$), a very strong association with family size ($\chi^2 = .812$, $p = 0.001$), a moderate association with land size ($\chi^2 = .487$, $p = 0.022$), a moderate relationship with gender ($\chi^2 = .446$, $p = .035$), a strong association with religion affiliation ($\chi^2 = .624$, $p = 0.002$), a very strong association with knowledge on CRA practices ($\chi^2 = .732$, $p = 0.004$), a very strong association with membership to a farmer group ($\chi^2 = .793$, $p = 0.002$), and a very strong association with credit access ($\chi^2 = .855$, $p = .000$). However, adoption of CRA practices presented no significant association with factors like level of education, farming experience, marital status, tribe and information access.

4.5.2 Multivariate analysis for CRA practices adoption and associated factors

Significant associations between independent variables (factors) and dependent variable (adoption of CRA practices) were determined using logistic regression at 95% confidence interval and 5% level of probability.

Table 4.7: Logistic regression results for the factors affecting the adoption of CRA practices

Adoption of CRA practices ^a		B	Std. Error	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
						Lower Bound	Upper Bound
Yes	Intercept	-17.252	1.791	.000			
	Age	In years	1.346	.581	.021	3.842	1.230 3.997
	Education	In years	-.009	.045	.833	.991	.908 1.081
	Family size	Members	2.316	.691	.001	2.862	1.432 10.937
	Experience in farming	In years	-.069	.042	.099	.934	.860 1.013
	Size of land	Acres	2.165	.973	.026	8.712	1.294 15.658
	Gender	Male	.770	.372	.038	2.159	1.042 4.474
		Female	0 ^b	.	.	.	.
	Marital status	Single	-1.256	1.001	.210	.285	.040 2.027
		Married	-1.459	.937	.119	.232	.037 1.458
		Widowed	-1.854	1.099	.091	.157	.018 1.349
		Separated	0 ^b	.	.	.	.
	Religion	Catholic	.143	.296	.629	1.153	.646 2.059
		Anglican	.017	.015	.247	1.017	.988 1.046
		Muslim	.511	.560	.321	2.974	.974 2.974
		Others	0 ^b	.	.	.	.
	Income status	High	.941	.633	.137	2.562	.742 8.850
		Medium	1.231	.676	.068	3.425	.911 12.873
		Low	0 ^b	.	.	.	.
	Knowledge on CRA practices	Yes	.900	.343	.005	2.460	1.255 4.822
		No	0 ^b	.	.	.	.
	Group membership	Yes	-1.072	.345	.002	.342	.174 .674
		No	0 ^b	.	.	.	.
	Access to credit	Yes	2.174	.765	.002	1.929	.817 2.055
		No	0 ^b	.	.	.	.
	Reoccurrence of pest and diseases	Yes	-.148	.158	.347	.862	.633 1.175
		No	0 ^b	.	.	.	.

- a. Dependent variable is: Adoption of CRA practices
- b. The reference category is: no
- c. This parameter is set to zero because it is redundant.

Results of the logistic regression model for the potential factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement were presented in table 4.7 above. The coefficients explained the changes in the probabilities of the outcome as a result of a unit change in the explanatory variables. Adoption of climate resilient agricultural practices was used as the outcome category in the equation. Thirteen factors were hypothesized and only seven remained statistically significant at multivariate level including age, family size (labour), size of land, gender, off-farm activities, group membership and access to credit.

The coefficient of age was a positive and had a significant association with adoption of climate resilient agricultural practices at 5 percent. Old age increased the log of the probability of farmer's adoption of climate resilient agricultural practices by 3.842 implying that a unit increment in age increased the chances of adopting climate resilient agricultural practices by 3.8 [AOR = 3.842; (95% CI: 1.230 - 3.997); $p = .021$]. The stated null hypothesis that there was no significant association between age and adoption of climate resilient agricultural practices was rejected.

Family size increased the log of the probability of households adopting climate resilient agricultural practices by 2.862. Bigger households were 2.8 times more likely to adopt of climate resilient agricultural practices compared to small households [AOR = 2.862; (95% CI: 1.432 - 10.937); $p = .001$]. The stated null hypothesis no significant association between family size and adoption of climate resilient agricultural practices was rejected.

Land size increased the log of the probability of households adopting climate resilient agricultural practices by 8.712. Farmers with big sized land had 8.7 chances of adopting climate resilient agricultural practices compared to those with small sized land [AOR = 8.712; (95% CI: 1.294 - 15.658); $p = .026$]. The stated null hypothesis no significant association between size of land and adopt of climate resilient agricultural practices was rejected.

Similarly, the coefficient of gender was a positive and had a significant association with farmer's adoption of climate resilient agricultural practices at 5 percent. Males were 2.2 times more likely to adopt of climate resilient agricultural practices compared to females [AOR = 2.159; (95% CI: 1.042 - 4.474); $p = .038$]. The earlier stated null hypothesis was rejected.

Similarly, having knowledge on CRA practices increased the log of the probability of adopting of climate resilient agricultural practices by 2.460. Farmers with knowledge on CRA practices had 2.4 chances of adopting the practices compared to those who had no knowledge [AOR = 2.460; (95% CI: 1.255 - 4.822); $p = .005$]. In this case, the stated null hypothesis that there was no association between having knowledge on CRA practices and adoption of CRA practices was rejected.

Unlike presence of off-farm activities, the coefficient of group membership was negative but had a significant association with farmer's adoption of CRA practices implying that belonging to a group decreased the log of the probability of farmer's adopting CRA practices. Farmers who belonged to groups were .342 times less likely to adopt CRA practices compared to those that never belonged to groups [AOR = .342; (95% CI: .174 - .674); $p = .022$]. The stated null hypothesis that there was no significant association between group membership and adoption of CRA practices status was rejected.

Lastly, access to credit increased the log of the probability of adopting of climate resilient agricultural practices by 1.929. Farmers with access to credit services had 1.929 chances of adopting climate resilient agricultural practices compared to those that who had no access to credit [AOR = 1.929; (95% CI: .817 - 2.055); $p = .002$]. In this case, the stated null hypothesis that there was no association between access to credit and adoption of CRA practices was rejected. Majority of the factors were found significant indicating that the low adoption of climate resilient agricultural practices is not only justified by a single factor but a combination of multiple factors.

4.6 Available adaptation possibilities that can aid resilience to climate change and variability for smallholder farmers

This section addresses research objective four which sought to identify the available adaptation possibilities that can aid resilience to climate change and variability for smallholder farmers. The objective was analyzed at Univariate level using frequency counts and percentages as presented in table 4.8 below.

Table 4.8: Available adaptation possibilities that can aid craft resilience to climate change and variability

Adaptation possibilities	Total (n=322)
Increasing water supply through rain water harvesting	31 (9.6%)
Integrated pest and disease control	27 (8.4%)
Boosting community education and awareness programs	30 (9.3%)
Promoting labour saving technologies	39 (12.1%)
Establishing off farm income projects	16 (4.9%)
Promoting agroforestry	47 (14.6%)
Capacity building through training and skills development	51 (15.8%)
Credit extension	19 (5.9%)
Widening extension coverage	25 (7.8%)
Promoting climate resistant crop and animal varieties	37 (11.5%)

Results for the available adaptation possibilities that could aid resilience to climate change and variability in the area were presented in table 4.8 above. Majority (15.8%) of the respondents mentioned capacity building through training and skills development, 14.6% promoting agroforestry, 12.1% introducing and promoting labour saving technologies, 11.5% talked of promoting climate resistant crop and animal varieties and 9.6% mentioned increasing water supply through rain water harvesting. Moreover, 9.3% of the respondents mentioned boosting community education and awareness programs, 8.4% integrated pest and disease control, 7.8% talked of widening extension coverage to reach farmers in hard to reach remote areas, 5.9% and 4.9% mentioned credit extension and establishing off farm income projects respectively.

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents discussion, conclusion and recommendations in line with the study objectives. The discussion entails drawing inferences between the current findings and previous studies conducted by other scholars who conducted studies in related areas in other areas world over.

5.2 Discussion of findings

5.2.1 Different climate resilient agricultural practices used by smallholder farmers within the settlement camp

This section of the study discussion addresses research objective one which sought to establish the different climate resilient agricultural practices used by smallholder farmers within the settlement camp. The study found out the different climate resilient agricultural practices used by smallholder farmers within the settlement camp. Agro-forestry emerged as the practice that was widely practiced by farmers. There were lots of combinations of food products including crops and fruits and trees especially planted around homesteads and along fences on the farm boundaries or on crop- or pasture land. Agro-forestry creates a more diverse, productive and ecologically sound land use and environment thus contributing to climate resilience. Agroforestry is the cultivation and use of trees and shrubs with crops and livestock in agricultural systems. It seeks positive interactions between its components, aiming to achieve a more ecologically diverse and socially productive output from the land than is possible through conventional agriculture. The most commonly adopted system was a banana and coffee system although there were other systems like mango trees with ground nuts and grass land for cattle with eucalyptus trees. To support the findings, Sahman & Zhang, (2018) stated that agro forestry is a set of land-use practices involving the deliberate combination of trees with agricultural crops

and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence. There are lots of possible combinations of food products including crops and fruits, fodder, mulch/green manure and timber. Trees may, for example, be planted around homesteads (home garden), along fences, on the farm boundaries or on crop- or pasture land. The introduction of trees or shrubs creates a more diverse, productive and ecologically sound land use and environment.

Secondly, a section of respondents reported use of compost and organic manure. The use of compost and organic manure is a critical climate-resilient agricultural practice adopted by smallholder farmers to enhance their ability to cope with the challenges posed by climate change. This practice involves enriching the soil with natural sources of nutrients, which helps improve soil health, water retention, and overall agricultural productivity. Compost and organic manure contain organic matter that improves soil structure, allowing for better water infiltration and retention. This is particularly important in areas prone to drought and erratic rainfall. Compost and organic manure practices are used with an aim of building soil resilience, improve soil health, building soil carbon and increasing water retention capacity of soil are important factors that improve resilience. This finding was in agreement with Osumba et al., (2020) who noted that compost and organic manures are very key in strengthening soil properties including nutrients, aeration and water holding capacity.

More so, respondents talked about water-smart technologies as another climate resilient agricultural practices used by smallholder farmers within the settlement camp. Water-smart technologies are innovative and adaptive approaches that smallholder farmers adopt to effectively manage water resources, enhance water use efficiency, and build climate resilience within their agricultural systems. Water-smart technologies like micro-irrigation, rainwater

harvesting structure, cover-crop method, reuse wastewater, and drainage management are widely adopted in the camp with an aim of improving productivity. These practices have supported farmers to decrease the effect of variations of climate. Moreover, these technologies help farmers address the challenges of changing climate patterns, water scarcity, and extreme weather events. In support of the findings Liben et al., (2018) also reported water harvesting and management technologies as a strategy to secure water resources in climate change affected areas. Therefore, provision of supplementary water to croplands through irrigation and use of efficient irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns.

Respondents further mentioned the use of improved crop varieties such as hybrid varieties which are tolerant to climate variations. Patterns of drought may need various sets of adaptive forms. Drought tolerance is the ability to which a plant maintains its biomass production during arid or drought conditions. The use of improved crop varieties has been a vital climate-resilient agricultural practice that smallholder farmers have adopted to enhance their ability to withstand the challenges posed by climate change. Improved crop varieties, also known as climate-smart varieties, are developed through breeding techniques to exhibit traits that help them thrive in changing environmental conditions. Some plants are naturally adapted to dry conditions, surviving with protection mechanisms such as desiccation tolerance, detoxification, or repair of xylem embolism. Other plants, specifically crops like corn, wheat, and rice, have become increasingly tolerant to drought with new varieties created via genetic engineering. In support of the findings, Woolf et al., (2018) stated that the mechanisms behind drought tolerance are complex and involve many pathways which allows plants to respond to specific sets of conditions at any given time.

Respondents further reported soil fertility management as part of the climate resilient agricultural practices adopted by smallholder farmers. Soil fertility management is a crucial climate-resilient agricultural practice adopted by smallholder farmers to enhance their ability to cope with climate variability and change. This practice focuses on maintaining and improving soil health, nutrient content, and overall fertility, which in turn supports sustainable and productive agricultural systems. Managing these soils involves increasing its physical quality while maintaining or improving its fertility. The common practices used in managing soil fertility include applying organic substrates such as manures and composts and reducing tillage and retaining crop residues; conserving water. Incorporating climate-resilient practices of soil fertility management into smallholder farming systems has led to increased agricultural productivity, improved food security, and enhanced resilience in the face of climate challenges. In support of the findings, Escarcha et al. (2018) stated that a large proportion of agricultural land has been degraded due excessive disturbance, erosion, organic matter loss, salinization, acidification, or other processes that curtail productivity. Managing these soils involves increasing its physical quality while maintaining or improving its fertility. Practices that reclaim productivity and restore carbon storage include: nutrient amendments, applying organic substrates such as manures and composts and reducing tillage and retaining crop residues; conserving water.

5.2.2 Effect of selected climate resilient agricultural practices on the food production systems of the local's in the camp

This section addresses research objective two which sought to determine the effect of selected climate resilient agricultural practices on the food production systems of the local's in the camp. The association between selected climate resilient agricultural practices and food production were determined at multivariate level. From the analysis, the value of $R^2 = .856$ suggested that 85.6% variation in food production was explained by CRA practices such as agro-forestry,

tolerant crops and animals, water-smart technologies, soil fertility management, organic manure application and small scale irrigation while the remaining 14.4% was explained by other practices not mentioned in the study.

Agro forestry was the strongest predictor in food production whereby a unit change in agroforestry systems were found to affect household food production/security by 0.500. Agroforestry systems combine trees, crops, and sometimes livestock, leading to increased biodiversity within the farming system. The common agro forestry system practiced was coffee and banana, mango trees with ground nuts and millet gardens with timber trees. This diversity enhanced ecosystem resilience and provide various food sources. More, trees' root systems stabilize soil, prevent erosion, and enhance nutrient cycling leading to healthier soils that support higher crop yields. Agroforestry further offered a range of products like fruits, nuts, timber trees, and fodder, diversifying food sources and income streams. In their findings, Teklewold et al., (2019) stated that agroforestry has a substantial influence on household food production and food security by promoting sustainable and diverse farming systems that enhance resilience, increase yields, and improve nutritional intake. Agroforestry involves integrating trees, crops, and sometimes livestock within the same piece of land. Agroforestry practices need to be adapted to local conditions, considering factors such as climate, soil type, and community preferences. When implemented effectively, agroforestry significantly contributes to improved household food production and security while promoting sustainable and resilient agricultural systems.

Water-smart technologies influenced household food production/security by 0.367. Water-smart technologies especially rainwater harvesting and drip irrigation enhanced water use efficiency, ensuring crops receive adequate moisture even during water scarcity. But drip irrigation was practiced by limited number of farmers who could afford it in terms of cost. These technologies

reduced the impact of droughts and irregular rainfall patterns, helping maintain consistent crop yields. This study finding is in line with findings by Liben et al., (2018) who noted that water-smart technologies have a profound influence on household food production and food security by improving water management, enhancing agricultural productivity, and ensuring a more reliable and sustainable supply of food. Incorporating water-smart technologies into agricultural practices requires training, access to appropriate technologies and economic support for resources. By doing so, smallholder farmers can significantly enhance their household food production and security while contributing to broader sustainable water resource management.

Use of improved crop varieties affected household food production/security by 0.305. Tolerant crop varieties and livestock breeds are specifically bred or selected to withstand climate-related challenges, such as drought, heat, pests, and diseases. Corn, wheat and rice and local breeds of cattle ensured more stable production even when faced with unfavorable climatic conditions, reducing the risk of crop failures or livestock losses. In support of the findings, Herlina & Prasetyorini, (2020) noted that use of improved crop varieties has a substantial influence on household food production and food security by enhancing crop yields, increasing resilience to environmental stressors, and providing a more diverse and nutrient-rich diet. Successful adoption of improved crop varieties depends on factors such as access to seeds, training, extension services, and market linkages. Tailoring these varieties to local agro ecological conditions and involving farmers in the selection process can maximize their benefits and contribute to improved household food production and security.

A change in soil fertility management practices by a unit was found to increase household food production/security by 0.271. Soil fertility management practices replenished essential nutrients, promoting healthy plant growth and higher yields. The enhanced soil structure through these

practices increases water retention in the soil, supporting crops during dry periods. Findings were also comparable to findings by Liben et al., (2018) who argued that adoption of improved soil fertility conservation practices coupled with optimum inorganic fertilizer use along with organic manure helps in improving the crop yields of the rain fed areas.

A unit increment in the use of compost and organic manures increased household food production/security by 0.211. Organic manure adds nutrients to the soil gradually, providing a steady supply for plant growth over time. It supports beneficial soil microorganisms that aid in nutrient cycling and disease suppression as well as enhances soil structure, water retention, and aeration, resulting in healthier plants and higher yields. These study findings were in agreement with Teklewold et al., (2019) who revealed that addition of organic manure in agriculture is nothing but a concept of resource saving in agriculture crop production that strives to achieve acceptable profits together with high and sustained production levels simultaneously conserving the environment. They revealed that this agriculture system includes minimum tillage, cover crops and crop rotation enhancing soil and water conservation, controlling soil erosion, improves soil physical characteristics, chemical parameters and biological activities, ultimately improves the soil fertility and productivity. It represents a practical concept to achieve improved soil health and better soil-crop-nutrient water management leading to ecologically and environmentally sustainable agriculture.

5.2.3 Potential factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement

This section addresses research objective two which sought to establish the potential factors limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement. Significant associations between independent variables (factors) and dependent

variable (adoption of CRA practices) were determined using logistic regression at 95% confidence interval and 5% level of probability.

Age was identified as a strong predictor in the adoption of climate resilient agricultural practices. Old age increased the log of the probability of farmer's adoption of climate resilient agricultural practices where by the more the age, the more the chances that an individual would adopt and use the practices. However, there is a controversy in the literature when explaining the relationship between age and level of farmer adoption of any new farm technology. Older farmers are rigid in adopting new technologies. Perhaps this is because of investing several years in particular practices, which makes them unwilling to risk by trying out completely new farming methods. In support of the findings, Harvey et al. (2018), age of a farmer may positively or negatively influence the decision to adopt new technologies. Older farmers have more experience in farming challenges and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher likelihood of adopting the practice.

The study revealed that households with bigger number of young and energetic persons were more likely to adopt of climate resilient agricultural practices compared to families with smaller number of young and energetic persons. The bigger the number of energetic members in the household, the more the chances of getting labour. Labour is an important constraint in adoption of new technologies particularly those technologies that are labour-intensive. Labour availability can be measured as the proportion of household members who contribute to farm work. The proportion of household members available to provide labour positively influence adoption of agricultural practices. The number of household members who provide farm labour is positively associated with probability of participating in soil fertility management practices. This finding is comparable to findings by Mbuli et al., (2021) who mentioned that due to high labour demand

for applying animal manure, households with high number of members working on the farm are more effective since household labour is the most important source of labour supply for smallholder households, given that low incomes constrain hiring labour. Moreover, there are moral hazards associated with hired labour calling for considerable supervision which raises the real cost of household labour beyond the observed wage rate. Therefore, lack of adequate labour accompanied by inability to hire labour can seriously hinder participation in soil fertility management practices.

Land size increased the probability of households adopting climate resilient agricultural practices. Farmers with big sized land had more chances of applying climate resilient agricultural practices than those with small sized land. This study finding is in agreement with Dinesh and Vermeulen (2016) who stated that farm size can positively influence adoption because farmers with large farm sizes of land can experiment new technologies on a portion of land without worrying about endangering the family food security. In addition, the benefits from large-scale adoption of new technologies are absolutely large for larger farms.

The coefficient of sex was a positive and had a significant association with farmer's adoption of climate resilient agricultural practices where by females were more likely to adopt of climate resilient agricultural practices compared to males. It was of no doubt that women would adopt climate resilient agricultural practices compared to males because traditionally females tend to dominate in household activities that bring food security or non-cash family activities. In other words, women are more involved in activities like small animal rearing, crop planting, weeding, harvesting. Dessie et al., (2019) contradicts the findings by asserting that the household head is the implicit key decisions maker for the household. Male-headed households in developing

countries have a higher access to resources and information that give them greater capacity to adopt.

Similarly, having knowledge on CRA practices increased the probability of adopting of climate resilient agricultural practices. Farmers with knowledge on CRA practices had more chances of adopting the practices than those who had no knowledge. The greatest constraint faced by poor farmers to use of recommended agricultural practices are lack of knowledge. In order to overcome this constraints, there is need for great investment in extension services so that farmers get the right message at the right time. In comparison with the findings, Kebede et al., (2019) stated that practice-oriented research, capacity-building and extension, as well as improving access to agriculture information are some of the key strategies that can improve uptake of agricultural technologies by farmers.

Group membership was negative but had a significant association with farmer's adoption of CRA practices implying that belonging to a group decreased the log of the probability of farmer's adopting CRA practices. Farmers who belonged to groups were less likely to adopt CRA practices compared to those that never belonged to groups. The greatest constraint to group members' adoption of CRA practices was lack of group owned land where they could collaboratively practice CRA. This finding contradicts with findings by Sahman & Zhang, (2018) who once said that group memberships are more supportive of the innovation to contribute to the adaptation of CRA practices.

Access to credit increased the probability of adopting of climate resilient agricultural practices. Farmers with access to credit services had more chances of adopting climate resilient agricultural practices compared to those that who had no access to credit. In support of the findings, Rugege et al., (2017) stated that credit is very much useful to purchase inputs such as improved resilient

seeds and other inputs. Hence, access to credit is expected to influence the effectiveness of the adoption of resilient practices positively.

5.2.4 Available adaptation possibilities that can aid resilience to climate change and variability for smallholder farmers

This section addresses research objective four which sought to identify the available adaptation possibilities that can aid craft resilience to climate change and variability for smallholder farmers. A number of possibilities were suggested. For example, respondents mentioned the need to build farmer capacities through training and skills development as well as boosting their knowledge on different climate resilient agricultural practices. This could be achieved through periodical hands on trainings and FFSs. Through hands on training, farmers can be in a better position to acquire the necessary skills and knowledge required to apply and sustain the practices and technologies. This study finding is comparable to findings by Liben, et al., (2018) who argued that knowledge and skill generation need be seen as a process. The emergent questions are how poor, weak and vulnerable groups can be strengthened to experiment, enhance, share and spread their own knowledge and how they better can articulate their needs. Though, having considered extension as mainly an act of transforming technologies to farmers there is now a focus on participations of farmers in the innovation process and facilitation of experimentation among communities.

Another section of the respondents suggested the need to promote and encourage farmers to adopt agroforestry systems. The incorporation of trees and shrubs into the agricultural system helps to diversify and increase farm incomes and thus reduces the climatic risks in agricultural production. Increase in tree and shrub cover can help to minimize the effects of extreme weather occurrences, such as heavy rains, droughts, windstorms and the effects of frost. These prevent erosion, stabilize soils, raise water infiltration rates, halt land degradation, enrich biodiversity in

the landscape and increase ecosystem stability. Agroforestry is therefore important in helping farmers adapt to climate change by reducing their vulnerability to the effects of climate change, diversifying income sources and improving livelihoods. In support of the findings Anderegg et al., (2019) reported agroforestry as an important system that helps farmers adapt to climate change by reducing their vulnerability to the effects of climate change.

Respondents further mentioned the introduction and promotion of labour saving technologies since labour is always a major hindrance in the adoption of agricultural technologies. Due to high labour demand for adopting and applying agricultural practices like animal manure, households with low number of members working on the farm are always affected since in most families' household labour is the most important source of labour supply for smallholder households, more so the costs of hiring labour are very high. Therefore, adopting labour saving technologies like automated agricultural machines and sprayers is the best way to go. To compare the findings, Abera & Tesema, (2019) contends that labour is an important constraint in adoption of new technologies particularly those technologies that are labour-intensive. Labour availability can be measured as the proportion of household members who contribute to farm work. The proportion of household members available to provide labour positively influence adoption of soil fertility management practices. Due to high labour demand for applying animal manure, households with high number of members working on the farm are more effective since household labour is the most important source of labour supply for smallholder households, given that low incomes constrain hiring labour.

Respondents further talked of the need to promote climate resistant crop and animal varieties. Patterns of drought may need various sets of adaptive forms. To reach deficient downpour conditions, early maturing and drought-tolerant cultivars need to be promoted. These have

characteristics like early maturity, drought and pest resistance. On the other hand, tolerant breeds like local or indigenous breeds have the notion to forage for themselves. In nomadic systems, the animals show their owners when to move in search of new grasslands. Indigenous breeds have unique characters that are adapted to very specific eco-systems across the world. These unique characters are resistant to droughts, thermoregulation, ability to walk long distances, fertility and mothering instincts, ability to ingest and digest low-quality feed, and resistance to diseases. These livestock breeds may not be highly productive in terms of meat or milk production, but are highly adaptive to the unpredictable nature and have low resource footprints. In support of the findings, Jones & Tanner, (2016) stated that investing in climate resilient agriculture can only succeed if people understand the reasons why these investments are made, and what type of threats they are facing. Education, information and knowledge sharing can contribute to communication and thereby community involvement.

Respondents reported the need to increase water supply through rain water harvesting. Water harvesting is the collection of runoff for productive purposes. Instead of runoff being left to cause erosion, it can be harvested and utilized. The benefit of water harvesting is not only to secure and increase crop production in this dry place where rainfall is not always enough for crop production or to make crop production possible, but also to stop soil erosion and to recharge aquifers tapped for irrigation. The harvested runoff can involve different forms of surface runoff (sheet, rill, gully and stream flow) and the storage is either done in various structures like tanks, reservoirs or dams, or directly in soil or sand. For these smallholder farmers' food insecurity is often linked with water scarcity, poverty and stressed ecosystems. Thus, increasing the crop water productivity in this area is key since the productivity is often low but has the largest potential to be enhanced. This finding is comparable to findings by Ademola et al., (2016) who

asserted that an encouraged approach to enhance water productivity in smallholder agriculture is to adopt water harvesting (WH) and conservation technologies such as tied ridges and contour bunds, micro-basins, mulching, runoff harvesting, and other conservation farming technologies. Both yields and reliability of production can be significantly improved with this method.

Respondents mentioned the need to boost community education and awareness programs. Training, motivation and capacity building programs influence adoption behavior of farmers agricultural practices and technologies. Chandra & McNamara, (2018) asserted that awareness creation among farmers' increases successfulness of CRA. Thus availability of extension services is essential in scaling up CRA. External support especially by imparting more awareness and supplementing the communities with coping technologies has been clearly emphasized. Climate resilient agriculture initiatives are therefore of paramount importance.

Respondents further called for integrated pest and disease control. Integrated pest and disease control (IPM) is a comprehensive approach that can greatly assist farmers in building resilience to climate change and variability. By combining various pest and disease management strategies, IPM may enhance agricultural productivity, reduce crop losses, and contribute to overall farm resilience. IPM combines a range of techniques such as cultural practices, biological control, resistant crop varieties, and judicious use of pesticides. This diversity may minimize the reliance on any single approach, making the farming system more adaptable to changing climate conditions. IPM emphasizes the use of crop varieties that are naturally resistant to pests and diseases. IPM promotes the minimal use of chemical pesticides, reducing the risk of harmful environmental impacts and the development of pesticide-resistant pests. To effectively implement IPM, farmers need access to training, technical support, and information on the specific pest and disease pressures they face. Collaboration between farmers, agricultural

extension services, research institutions, and policymakers is crucial in developing and promoting IPM strategies that enhance farm resilience in the face of climate change. In support of the findings, Herlina & Prasetyorini, (2020) noted that integrated pest management solutions reduce the need for pesticides, while practices such as conservation tillage and organic farming can reduce pollutant loads entering waterways.

Respondents further recommended the need for widening extension coverage to reach farmers in their respective areas. For a long time, the Ugandan agricultural extension system has remained weak in terms of operations resulting from underfunding, extension to farmer ratio in the area is high (1:1500) and area of coverage for one extension worker (all Sub County) is big. As a result, farmers in most remote rural settings are unable to access extension services. Therefore, strengthening the agricultural extension system through additional budget allocation means that rural farmers can fully access the service hence improving on their production capacity. This study finding concurs with FAO (2017) which indicated that the role of extension is to educate the people to understand that they are an agent of change and are able to influence their communities by addressing their immediate problems through application of acquired technology. The process of extension education is one of working with people, not for them; of helping people become self-reliant, not dependent on others, of making people the central actors in the drama, not stage hands or spectators; in short, helping people by means of education to put to use useful knowledge that works for them.

Lastly, respondents mentioned to widen credit extension. Credit extension plays a vital role in helping farmers build resilience to climate change and variability by providing them with the financial resources they need to adopt climate-resilient practices and technologies. Farmers need funds to invest in climate-resilient technologies such as drought-tolerant seeds, improved

irrigation systems, weather monitoring equipment, and energy-efficient machinery. Credit may enable farmers to purchase these technologies, enhancing their ability to cope with changing climate conditions. Farmers can use credit to diversify their income sources, such as adopting agroforestry, livestock rearing, or other non-traditional activities. Diversification spreads risk, allowing farmers to maintain income even if one aspect of their agricultural activities is impacted by climate-related events. Therefore, lack of credit limits farmer's capacity to invest in good management practices. This study finding agrees with Abera & Tesema, (2019) who stated that cash is essential in hiring labour and purchasing of farm inputs like seeds and animal manure. Mugagga and Buyinza (2013) argued that farmers pay cash for the raw materials in promoting a technology.

5.3 Conclusions

In conclusion, the study findings show that there are different climate resilient agricultural practices used by smallholder farmers within the settlement camp such as agro forestry which involved a combination of trees, crops and livestock, leading to increased biodiversity within the farming system. Coffee with banana was the common system of agroforestry in Oruchinga but there were other agro forestry systems including mango trees with banana and millet gardens with eucalyptus trees. Agro-forestry enhanced soil stability, prevent erosion, and enhance nutrient cycling leading to healthier soils that support higher crop yields. In addition, it was revealed that trees planted with crops provide shade, act as windbreaks, regulate humidity and create favorable microclimates for crops and animals. This was the commonly practiced CRA. However, there other CRA practices such as use of improved crop varieties and livestock breeds, water-smart technologies like rain water harvesting, soil fertility management, use of compost and organic pesticides and small scale irrigation.

The research revealed that climate resilient agricultural practices had a statistically significant effect on food production systems of smallholder farmers in the camp. This is because a unit change in practices like agro forestry, water-smart technologies, use of improved crop varieties, soil fertility management and use of compost and organic manures were found to influence food production/security at household level.

This research showed that factors like age, family size (labour), size of land, gender, off-farm activities, group membership and access to credit are key in limiting the adoption of climate resilient agricultural practices in and around Oruchiga settlement. Whereby, age and family size were identified as strong predictors in the adoption of climate resilient agricultural practices. The study revealed that households with bigger number of young and energetic persons were more likely to adopt climate resilient agricultural practices compared to families with smaller number of young and energetic persons. The bigger the number of energetic members in the household, the more the chances of getting labour.

The study further concludes that capacity building through training and skills development, agroforestry promotion, promotion of labour saving technologies, promotion of climate resistant crop and animal varieties, increasing water supply, boosting community education and awareness programs, integrated pest and disease control as well as widening extension coverage as some of the adaptation possibilities that could aid craft resilience to climate change and variability in the area.

5.4 Recommendations

Based on the study findings, the following recommendations were made in line with the study objectives.

Since the study discovered that the application of different climate resilient agricultural practices had some significant effect of food production systems, it is paramount that these specific or a combination of practices be promoted to boost production in the area.

Government extension agents should intensify on the effort of educating farmers on the usefulness of climate resilient agricultural practices for sustainable production and environmental protection. More education and awareness is needed to change the perceptions of farmers about climate resilient agricultural practices so as to design strategies to address the problem of low productivity in the area.

Awareness campaigns aimed at discouraging use of inappropriate practices should be done by government in conjunction with camp leadership stakeholder and farmers organizations.

The government through the ministry of local governments should increase rural investments to create job opportunities among smallholder farmers. This can create off-farm employment opportunities that could give farmers enough finance to invest in appropriate climate resilient farming practices.

Lack of capital to invest is among the key factors limiting farmer's adoption of climate resilient agricultural practices, government should intervene and avail credit services to the farmers coupled with prior financial literacy. This can be achieved through establishing village banks, and encouraging financial institutions to give farmers loans at low interest rate.

More education is needed through programmes like adult learning. This would help farmers acquire a specific level of knowledge needed to use specific agricultural technologies. This is because a big number of farmer were partially educated which perhaps explained their lack of understanding on certain practices.

There is need to change the mindset and perceptions of the community towards the use of climate resilient agricultural practices. This can be achieved through organizing educational seminars and workshops at parish and village level.

There is need for more capacity building and external support. This can be achieved through providing agricultural advisory services. To boost domestic production, policy makers that should encourage and provide technical assistance to households that practice agricultural practices that promote sustainable soil fertility and productivity as well as encourage farmers to participate in larger CRA packages.

5.5 Areas for further research

The study recommends for further research on other factors other than socio-economic factors that influencing uptake of climate resilient agricultural practices. A further study to identify these factors is needed (such as institutional and environmental). In addition, further studies can be conducted to ascertain the effect of differing socio-demographic characteristics of farmers on the uptake level of climate resilient agricultural practices.

References

- Abera, N., & Tesema, D. (2019). Perceptions and Practices of Climate Change Adaptation and Mitigation Strategies among Farmers in the Konta Special District, Ethiopia. *Environmental & Socio-Economic Studies*, 7(4), 1–16. <https://doi.org/10.2478/environ-2019-0019>
- Accorsi, R. et al. 2017. A climate driven decision-support model for the distribution of perishable products. *Journal of Cleaner Production*, 165, 917-929.
- Adela, F. A., Aurbacher, J., & Abebe, G. K. (2019). Small-scale irrigation scheme governance-poverty nexus: evidence from Ethiopia. *Food Security*, 11(4), 897-913.
- Ademola, A., Manning, L. and Azadi, H (2016): Agribusiness Innovation: A pathway to Sustainable Economic Growth in Africa. *Trends in food science and technology*, 55 pp.88-104
- Aleminew, A., & Alemayehu, M. (2020). Soil Fertility Depletion and Its Management Options under Crop Production Perspectives in Ethiopia: A Review. *Agricultural Reviews*, 41(2).
- Amare, D., Wondie, M., Mekuria, W., & Darr, D. (2019). Agroforestry of smallholder farmers in Ethiopia: practices and benefits. *Small-scale Forestry*, 18(1), 39-56.
- Amin, A., Mubeen, M., Hammad, H., & Jatoi, W. (2015). Climate Smart Agriculture: an approach for sustainable food security. *Agricultural Research Communication*. 2015. 13-21.
- Anderegg, W. R. L., Trugman, A. T., Bowling, D. R., Salvucci, G., & Tuttle, S. E. (2019). Plant Functional Traits and Climate Influence Drought Intensification and Land– atmosphere

- Feedbacks. *Proceedings of the National Academy of Sciences of the United States of America*, 116(28), 14071–14076. <https://doi.org/10.1073/pnas.1904747116>
- Assefa, T., Jha, M., Worqlul, A. W., Reyes, M., & Tilahun, S. (2019). Scaling-Up Conservation Agriculture Production System with Drip Irrigation by Integrating MCE Technique and the APEX Model. *Water*, 11(10), 2007.
- Assefa, T., Jha, M., Worqlul, A. W., Reyes, M., & Tilahun, S. (2019). Scaling-Up Conservation Agriculture Production System with Drip Irrigation by Integrating MCE Technique and the APEX Model. *Water*, 11(10), 2007.
- Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of Smallholder Farmers' Adaptation Strategies to the Effects of Climate Change: Evidence from Northern Uganda. *Agriculture and Food Security*, 10(1), 1–14. <https://doi.org/10.1186/s40066-020-00279-1>
- Aune, J. B. (2020). The Prospects for Conservation Agriculture in Ethiopia. In *Climate Impacts on Agricultural and Natural Resource Sustainability in Africa* (pp. 23-39): Springer.
- Ballard, G., Chamberlin, L., Elliott, M., Hickey, C., Jahncke, J., Reiter, M. & Warzybok, P. (2018). Setting Four Conservation Priorities in a Changing World: Site Guide.
- Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder Farmers' Sdaptation to Climate Change and Determinants of Their Adaptation Decisions in the Central Rift Valley of Ethiopia. *Agriculture and Food Security*, 6(1), 1–13. <https://doi.org/10.1186/s40066-017-0100-1>.
- Bernier, Q. Meinzen-Dick, R., Kristjanson, P., Haglund, E., Kovarik, C., Bryan, E., Ringler, C. & Silvestri S. (2015). Gender and Institutional Aspects of ClimateSmart Agricultural

- Practices: Evidence from Kenya. CCAFS Working Paper No. 79. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark
- BFS/USAID, C. (2017). Climate-Smart Agriculture in Ethiopia. CSA Country Profiles for Africa Series. *International Center for Tropical Agriculture (CIAT); Bureau for Food Security, United States Agency for International Development (BFS/USAID)*.
- British Columbia. 2020. Best practices for prevention of saltwater intrusion [online]. [cited 1 March 2021]. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/saltwaterintrusion_factsheet_flnro_web.pdf
- Buckle, C. (2020). Touching, scrolling and swooping: Performing and representing migrant stories through geospatial technologies. *Geoforum*, 111, 83-93.
- Canevari-Luzardo, L. M. (2019). Value chain climate resilience and adaptive capacity in micro, small and medium agribusiness in Jamaica: a network approach. *Regional Environmental Change*, 19(8), 2535-2550.
- Chandra, A., & McNamara, K. E. (2018). Climate-Smart Agriculture in Southeast Asia: Lessons from Community-Based Adaptation Programs in the Philippines and Timor-Leste. In *Resilience* (pp. 165-179). Elsevier.
- CRAFT. 2020. Climate Resilient Farmer Field Schools Handbook.
- Dekens J, MAK FB (2012). Promoting an Integrated Approach to Climate Adaptation: Lessons from the coffee value chain in Uganda.

- Dessie, A. B., Abate, T. M., Mekie, T. M., & Liyew, Y. M. (2019). Crop diversification analysis on red pepper dominated smallholder farming system: evidence from northwest Ethiopia. *Ecological Processes*, 8(1), 1-11.
- Dinesh D, Vermeulen S (2016). Climate change adaptation in agriculture: practices and technologies. Messages to the SBSTA 44 agriculture workshops.
- Escarcha, J. et al. 2018. Livestock under climate change: A systematic review of impacts and adaptation. *Climate*, 6(3), 54.
- Eshete, D. G., Sinshaw, B. G., & Legesse, K. G. (2020). Critical review on improving irrigation water use efficiency: Advances, challenges, and opportunities in the Ethiopia context. *Water-Energy Nexus*.
- Ewbank, R., Perez, C., Cornish, H., Worku, M., & Woldetsadik, S. (2019). Building resilience to El Niño-related drought: experiences in early warning and early action from Nicaragua and Ethiopia. *Disasters*, 43, S345-S367.
- FAO & UNDP. 2018. Institutional Capacity Assessment Approach for National Adaptation Planning in the Agricultural Sectors [online]. [Cited 23 February 2021]. <http://www.fao.org/3/I8900EN/i8900en.pdf>
- FAO, IFAD., & UNICEF. (2020). WFP and WHO. The state of food security and nutrition in the world 2020. Transforming food systems for affordable health diets. Rome, FAO. 2020.
- FAO. (2017a). Key Messages Monitoring and Evaluation for Climate-resilient agriculture: Scope, Purposes, Frameworks and Concepts. Retrieved from <http://www.fao.org/climate-smart-agriculture-sourcebook/enabling-frameworks/modulec9-monitoring-evaluation/c9-overview/en/>.

- FAO. (2017b). *Tracking Adaptation in Agricultural Sectors*. <https://doi.org/10.18356/87fe25de-en>.
- FAO. 2019. Building resilience for adaptation to climate change in the fisheries and aquaculture sector [online]. [Cited 23 February 2021]. <http://www.fao.org/3/i3084e/i3084e08.pdf>
- Food and Agricultural organization (FAO). 2015. A Shift in Global Perspective: institutionalizing Farmer Field School. FAO. Rome.
- Gezie, M. (2019). Farmer's response to climate change and variability in Ethiopia: A review. *Cogent Food & Agriculture*, 5(1), 1613770.
- Harvey, C. A., Saborio-Rodríguez, M., Martinez-Rodríguez, M. R., Viguera, B., Chain-Guadarrama, A., Vignola, R., & Alpizar, F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. *Agriculture and Food Security*, 7(1), 1–20. <https://doi.org/10.1186/s40066-018-0209-x>.
- Herlina, N., & Prasetyorini, A. (2020). Effect of Climate Change on Planting Season and Productivity of Maize (*Zea mays* L.) in Malang Regency. *Jurnal Ilmu Pertanian Indonesia*, 25(1), 118–128. <https://doi.org/10.18343/jipi.25.1.118>
- Ho, T. T., & Shimada, K. (2019). The Effects of Climate Smart Agriculture and Climate Change Adaptation on the Technical Efficiency of Rice Farming—An Empirical Study in the Mekong Delta of Vietnam. *Agriculture (Switzerland)*, 9(99), 1–20. <https://doi.org/10.3390/agriculture9050099>.

- Intergovernmental Panel on Climate Change (IPCC), (2014). Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. *et al.*, (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Integrated Food Security Phase Classification (IPC) (2017). UGANDA – Current Acute Food Insecurity Situation. Accessed from:
https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Uganda_AcuteFI_Jan-March2017.pdf
- Iscaro J (2014). The Impact of climate change on coffee production in Colombia and Ethiopia. Global Majority E-Journal, 5(1):33-43.
- Jaramillo J, Setamou M , Muchugu E, Chabi-Olaye A , Jaramillo A, Mukabana J, Maina J, Gathara S and Borgemeister C (2013). Climate change or urbanization? Impacts on a traditional coffee production system in East Africa over the last 80 years. PloS one 8(1):e51815.
- Jassogne L, Läderach P, Asten VP (2013). The Impact of Climate Change on Coffee in Uganda: Lessons from a case study in the Rwenzori Mountains. Oxfam Policy and Practice: Climate Change and Resilience 9(1):51-66.
- Jones, L. & Tanner, T., (2016). “Subjective resilience”: using perceptions to quantify household resilience to climate extremes and disasters. Regional Environmental Change
- Kebede, B. T., Abdisa, T. O., & Berkessa, A. J. (2019). Review on The Expected Role of Climate Smart Agriculture on Food System in Ethiopia.

- Kedir, N., Coninx, I., Vonk, R., Tefera, T., Descheemaeker, K., & Hutjes, R. (2021). Farmers' Perceptions and their Implications to Climate-Proof Food Security Programmes. In *Handbook of Climate Change Management: Research, Leadership, Transformation* (pp. 1-25): Springer International Publishing.
- Kpadonou, R. A. B., Owiyo, T., Barbier, B., Denton, F., Rutabingwa, F., & Kiema, A. (2017). Advancing Climate-Smart-Agriculture in Developing Drylands: Joint Analysis of The Adoption of Multiple On-farm Soil and Water Conservation Technologies in West African Sahel. *Land Use Policy*, 61, 196–207. <https://doi.org/10.1016/j.landusepol.2016.10.050>.
- Liben, F., Tadesse, B., Tola, Y., Wortmann, C., Kim, H., & Mupangwa, W. (2018). Conservation agriculture effects on crop productivity and soil properties in Ethiopia. *Agronomy Journal*, 110(2), 758-767.
- Maitra, S., Palai, J. B., Manasa, P., & Kumar, D. P. (2019). Potential of Intercropping System in Sustaining Crop Productivity. *International Journal of Agriculture Environment and Biotechnology*, 12(1), 39–45. <https://doi.org/10.30954/0974-1712.03.2019.7>.
- Mbuli, C. S., Fonjong, L. N., & Fletcher, A. J. (2021). Climate Change and Small Farmers' Vulnerability to Food Insecurity in Cameroon. *Sustainability*, 13(1523), 1–16.
- Mengistie, D., & Kidane, D. (2016). Assessment of the impact of small-scale irrigation on household livelihood improvement at Gubalafto District, North Wollo, Ethiopia. *Agriculture*, 6(3), 27.
- Michler, J. D., & Josephson, A. L. (2017). To specialize or diversify: Agricultural diversity and poverty dynamics in Ethiopia. *World Development*, 89, 214-226.

- Mlenga, D. H., & Maseko, S. (2015). Factors influencing adoption of conservation agriculture: A case for increasing resilience to climate change and variability in Swaziland. *Journal of Environment and Earth Science*, 5(22), 16-25.
- Mlenga, D. H., & Maseko, S. (2015). Factors influencing adoption of conservation agriculture: A case for increasing resilience to climate change and variability in Swaziland. *Journal of Environment and Earth Science*, 5(22), 16-25.
- Ogada, M., Mwambu, G., & Muchai, D. (2014). Farm Technology Adoption in Kenya: a Simultaneous Estimation of Inorganic Fertiliser and Improved Variety Adoption Decisions. *Agricultural and Food Economics*, 2 (1), 1-18.
- Olawuyi, S. O. (2020). Heterogeneous Treatment Effect Estimation of Participation in Collective Actions and Adoption of Climate-smart Farming Technologies in South – West Nigeria. *GeoJournal*, 85(5), 1309–1323. <https://doi.org/10.1007/s10708-019-10024-2>.
- Olayide, O. E; Kyle F.D (2017): Assessing Climate Resilient and Nutritious Cereal Crops in Nigeria. Policy Brief Issue 3 Number 4, 2017. University of Ibadan Centre for sustainable Development, Ibadan, Nigeria.
- Osumba J; Recha J; Kabuka G; Nzoka O; Asiimwe. B.W (2020): Transforming Agricultural Extension in Eastern Africa through Climate Resilient Farmer Field Schools.
- Ruel, M.T; Garrett, J; Yosef, S; Olivier, M (2017): Urbanization, food security and Nutrition. In: Nutrition and health in a Developing World [Cdepee, S (et al) eds]. New York, USA. Springer pp 705-724.

- Rugege, D. et al. 2017. Investing in on-farm and post-harvest resilience to climate change in smallholder value chains: Lessons from Rwanda [online]. [Cited 23 February 2021]. <https://cgspace.cgiar.org/handle/10568/80178>
- Sahman, K. M., & Zhang, D. (2018). Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. *Sustainability*, 10(3), 759.
- Shahzad, A., Ullah, S., Dar, A. A., Sardar, M. F., Mehmood, T., Tufail, M. A., ... Haris, M. (2021). Nexus on Climate Change: Agriculture and Possible Solution to Cope Future Climate Change Stresses. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-021-12649-8>.
- Shanabhoga, M. B. (2020). Adaptation Strategies by Paddy-growing Farmers to Mitigate the Climate Crisis in Hyderabad-Karnataka Region of Karnataka State, India. 12(5), 541–556. <https://doi.org/10.1108/IJCCSM-01-2020-0010>.
- Sharma, J., & Ravindranath, N. H. (2019). Applying IPCC 2014 framework for hazardspecific vulnerability assessment under climate change. *Environmental Research Communications*, 1(5), 051004.
- Sloat, L et al. 2020. Climate adaptation by crop migration. *Nature communications* 11.1, 1-9.
- Snilstveit, B., Stevenson, J., Langer, L., da Silva, N., Rabath, Z., Nduku, P., Polanin, J., Shemilt, I., Evers, J., & J Ferraro, P. 2019. Incentives for climate mitigation in the land use sector – the effects of payment for environmental services (PES) on environmental and socioeconomic outcomes in low- and middle-income countries: a mixed-method systematic review. *3ie Systematic Review 44*. London: International Initiative for Impact Evaluation (3ie) [online]. [Cited 23 February 2021].

- Susanti, E., Surmaini, E., & Estiningtyas, W. (2018). Parameter Iklim sebagai Indikator Peringatan Dini Serangan Hama Penyakit Tanaman. *Jurnal Sumberdaya Lahan*, 12(1), 59–70.
- Teklewold, H., Mekonnen, A., & Kohlin, G. (2019). Climate change adaptation: a study of multiple climate-smart practices in the Nile Basin of Ethiopia. *Climate and Development*, 11(2), 180-192.
- United Nations High Commission for Refugees Uganda (2014): Oruchinga fact sheet 2014.
- United Nations Office of the Special Adviser on Africa (2016): Comprehensive African Agricultural Development Program: <https://www.un.org/en/africa>.
- Velmurugan, A. et al. 2016. Managing waterlogging and soil salinity with a permanent raised bed and furrow system in coastal lowlands of humid tropics. *Agricultural Water Management*, 168, 56-67.
- Vignola, R., Harvey, C. A., Bautista-Solis, P., Avelino, J., Rapidel, B., Donatti, C., & Martinez, R. (2015). Ecosystem-based Adaptation for Smallholder Farmers: Definitions, Opportunities and Constraints. *Agriculture, Ecosystems and Environment*, 211, 126–132. <https://doi.org/10.1016/j.agee.2015.05.013>.
- Wezel, A et al. 2014. Agroecological practices for sustainable agriculture. A review. *Agronomy for sustainable development* 34.1 (2014): 1-20.
- Woolf, D., Solomon, D., & Lehmann, J. (2018). Land restoration in food security programmes: synergies with climate change mitigation. *Climate Policy*, 18(10), 1260-1270.

World Bank (2024). Food Security April Update. Accessed from:

[https://thedocs.worldbank.org/en/doc/40ebbf38f5a6b68bfc11e5273e1405d4-](https://thedocs.worldbank.org/en/doc/40ebbf38f5a6b68bfc11e5273e1405d4-0090012022/related/Food-Security-Update-CV-April-25-2024.pdf)

[0090012022/related/Food-Security-Update-CV-April-25-2024.pdf](https://thedocs.worldbank.org/en/doc/40ebbf38f5a6b68bfc11e5273e1405d4-0090012022/related/Food-Security-Update-CV-April-25-2024.pdf)

World Bank. (2021). *Resilience Rating System, A Methodology for Building and Tracking Resilience to Climate Change*. <https://doi.org/10.1596/35039>.

Yohannes, D. F., Ritsema, C., Solomon, H., Froebrich, J., & Van Dam, J. (2017). Irrigation water management: Farmers' practices, perceptions and adaptations at Gumselassa irrigation scheme, North Ethiopia. *Agricultural Water Management*, 191, 16-28.

APPENDICES

Appendix 1: Questionnaire for Household Heads

Dear respondent, am **Beinomugisha Boris**, a student of Bishop Stuart University Mbarara pursuing Master of Science in Climate Change and Food Security and conducting a research study on “**An assessment of the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District**”. The study is purely for academic reasons and you are kindly requested to honestly fill this questionnaire by providing your true answers to all questions. At all stages of the study, there will be no mention of your personal identity details. Therefore, you are kindly requested to answer the questions as requested.

Instructions: (Please tick the appropriate and fill in the blank spaces where necessary)

Section 1-A: Household Information

1. Name of respondent.....
2. Physical address
 - a) Village.....
 - b) Cell
3. Respondent's Sex
 - a) Female () b) Male ()
4. Age of the respondent.....years
5. Marital status
 - a) Single () b) Married () c) Widowed () d) Divorced ()
6. Level of education

a) None () b) Primary () c) Secondary () d) University ()

e) Others.....

7. Respondent's position in the household (with respect to the head)

a) Husband () b) wife () c) Son () d) Daughter ()

e) Relative ()

8. Nationality

a) Burundi () b) DRC () c) Rwanda () d) Others.....

Section 1-B. Household socio-economic background

9. Family Size: How Many a) Adults b) Children.....

10. Land ownership

a) Own the land () b) Hired and paid () c) given by government ()

11. Size of the land in hectares?

.....

12. Type of labour used on farm

a) Family () b) Hired ()

13. Type of farming practiced

a) Commercial farming () b) subsistence farming ()

14. Agricultural enterprises on the farm

	Crop enterprises		Animal enterprises
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	

15. Average income from the enterprise per month (Ugshs)

	Crop enterprises		Animal enterprises
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	

Section B: Food production and security situation among households

16 What is the source of food to your household?

a) Buying () b) Farming () c) Food Aid () d) both ()

17. Do you have access to land for farming/agriculture?

a) Yes () b) No ()

18. If yes, how did you acquire the land?

a) Purchase () b) rented () c) given by government ()

19. What is the average land under?

a) Crop production (hectares)

b) Animal production (hectares)

c) Residence (hectares)

20. Which food crops do you grow on your farm?

	Food crops	Yes	No
1	Rice		
2	Banana		
3	Maize		
4	Beans		
5	Millet		
6	Sorghum		
7	Beans		
8	Groundnuts		
9	Fruits		
10	Potato		
11	Cabbage		
12	Vegetables		
13	Cassava		
14	Other specify		

21. Which animals do you rear on your farm?

	Animals	Yes	No
1	Cattle		
2	Goats		
3	Ship		
4	Poultry		
5	Rabbits		
6	Ducks		
7	Other specify		

22. Do you normally produce adquate for your household?

a) Yes () b) No ()

23. If yes, describe the food production trend for your household in the past 4 years?

a) Increased () b) decreased () c) the same ()

24. If no, justify your answer in 22 above?

.....

25. How many meals do you usually take at your household in a day?

.....

26. Do you think the number of meals indicated 25 above are enough for your household members?

a) Yes () b) No ()

27. If no, justify your answer?

.....

.....

28. How many days in the last seven days did your household eat any of the food categories in the list below? (Tick appropriately the type of food eaten on each particular day) leave blank on each day a particular food was not eaten.

	Food item	7days ago	6 days ago	5 days ago	4 days ago	3 days ago	2 days ago	yesterday
1	Rice							
2	Wheat meal							
3	Maize meal							
4	Porridge							
5	Millet meal							
6	Sorghum meal							
7	Beans							
8	Groundnuts							
9	Meat							
10	Fresh milk							
11	Sour milk							
12	Poultry meat							
13	Eggs							
14	Fish							
15	Sukuma wiki							

16	Cabbage							
17	Vegetables							
18	Sweet potato							
19	Irish potato							
20	Cassava							
21	Others							

29. Have you experienced any food shortage at your household in the past 4 years?

a) Yes () b) No ()

30. If yes, what was the major cause (s) of the shortage?

.....
.....

31. If no, how have you maintained the food security situation in your household?

.....
.....

Section C: Climate resilient agricultural practices adopted among smallholder farmers

32. Have you noticed any changes in climate in this area?

a. Yes () b. No ()

33. If yes, (a) for how long have you noticed the changes?

a. Less than a year () b. 1-5 years () c. 6-10 years ()
d. More than 10 years ()

(b) Among 1-4 given below, indicate by filling in the box the code number of the most prevalent changes in climate that has been experienced in this area.

a. Increase in temperature ()

b. Erratic rainfall ()

c. Increased winds ()

d. Decreased rainfall ()

34. Have changes in climate impacted on water sources in this area?

1. Yes () 2. No ()

35. If yes, how?

.....
.....

36. Are there any climate resilient agricultural practices you have adopted to cope with climate change?

a. Yes () b. No ()

37. If yes, choose from the practices in the table below

	Practice	Yes	No
1	Using compost and organic pesticides		
2	Agroforestry		
3	Rainwater harvesting		
4	Soil and water management		
5	Use of improved crop varieties		
6	Use of improved livestock breeds		
7	Small scale irrigation		
8	Other specify		

38. If no, justify your answer?

.....

.....

39. To what extent has your agricultural productivity changed after implementing the farming practices mentioned in 37 above?

.....

.....

Section D: Effect of climate resilient agribusiness practices on the food production systems of the local's in the camp

38. Do the climate resilient agribusiness practices on your farm have any effect on food production in this area?

a) Yes () b. No ()

39. If yes, describe the effect using the table below

		Crop					
	Practice	Banana	Maize	Beans	Fruits	Vegetables	Others ...
1	compost and organic pesticides use						
2	Agroforestry						
3	Rainwater harvesting						
4	Soil and water management						
5	Cover cropping						
6	Use of improved crop varieties						

7	Irrigation						
8	Other specify						

40. If no, why do you think they are irrelevant?

.....

.....

Section E: Potential factors limiting the adoption of climate resilient agricultural practices

41. Could there be some factors limiting the adoption of climate resilient agricultural practices in this area?

1. Yes () 2. No ()

42. If yes, choose from the following factors

Factor	Yes	No
Poverty		
Reoccurrence of pest and diseases		
Limited knowledge on the practices		
Non-availability of labour		
High costs labour		
High cost of soil management		
Insufficient land		
Un-accessibility to credit services		
Poor extension coverage		
Persistent harsh weather conditions		
Others.....		

Section F: Available adaptation possibilities that can aid craft resilience to climate change and variability for smallholder farmers

43. Are there some available adaptation possibilities that can aid craft resilience to climate change and variability for smallholder farmers in this area?

1. Yes () 2. No ()

44. If yes, choose from the following adaptation possibilities

	Yes	No
Increasing water supply through rain water harvesting		
Integrated pest and disease control		
Community education about the practices		
Adopting labour saving technologies		
Establishing off farm income projects		
Promoting agroforestry		
Capacity building through training and skills development		
Credit extension		
Widening extension coverage		
Growing climate resistant crops		
Others.....		

45. Any last remarks?

.....
.....
.....

Thank you for your time

Appendix 1I: Interview Guide for agricultural extension workers

Dear respondent, am **Beinomugisha Boris**, a student of Bishop Stuart University Mbarara pursuing Master of Science in Climate Change and Food Security and conducting a research study on “**An assessment of the effect of climate resilient agricultural practices towards food security in Oruchinga camp-Isingiro District**”. The study is purely for academic reasons and you are kindly requested to honestly fill this questionnaire by providing your true answers to all questions. At all stages of the study, there will be no mention of your personal identity details. Therefore, you are kindly requested to answer the questions as requested.

1. Name of respondent.....
2. Date of the interview.....
3. Educational qualification.....
4. Position in the camp.....
5. Nationality.....
6. Which is the most common type of faming practiced in the camp?
7. What is most common type of labour used in agriculture in the settlement?
8. What is the source of food for the households in the camp?
9. Do households have access to agriculture land?
10. If yes, what is the average land size given to each household in the settlement (in hectares)?
11. What are the common crops grown by households in the camp?
12. Which type of animals are reared in the camp?

13. Describe the food security status for most households in the camp in the past 4 years?
14. Have you witnessed any change in household food production for the past 4 years?
15. If yes, what would be the cause?
16. Have you noticed any changes in climate in this area? If yes describe the cause and impact?
17. What climate resilient agricultural practices have farmers adopted to cope with climate change?
18. What effect do the climate resilient agribusiness practices have on food production in this area?
19. What are the potential factors limiting the adoption of climate resilient agricultural practices
20. What available adaptation possibilities could aid craft resilience to climate change and variability for smallholder farmers?

Thank you!