IMPACT OF CLIMATE VARIABILITY ON THE SOCIOECONOMIC LIVELIHOODS IN ARAPAI DIVISION, SOROTI CITY, UGANDA

BY

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DECLARATION

I, declare that "**IMPACT OF CLIMATE VARIABILITY ON THE SOCIOECONOMIC LIVELIHOODS IN ARAPAI DIVISION, SOROTI CITY, UGANDA**" is my research work and that the sources I cited are referenced. The work has not been submitted before for any degree or examination at any other university.

Signature……. Date…….

APIO RUTH

2021-01-03241

APPROVAL

This is to certify that this thesis was carried out by the candidate under my supervision

Dr. Mundu Mustafa

Supervisors' signature

……..

Dr. Susan Olaniyan

Supervisors' signature

…….

DEDICATION

I would like to dedicate this thesis to my Mum, Margie and my lovely family and above all to God Almighty.

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I would like to thank the Almighty God for the wisdom, strength, and courage given to me to complete the study. I extend my sincere and deep gratitude to my supervisors Dr. Mundu Mustafa and Dr. Susan Olaniyan, for their support and instruction. I commend their tireless guidance and supervision right from the beginning to the end of the study. A word of appreciation is owed from my heart for the support, prayers, encouragement, and confidence in me.

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LIST OF ABBREVIATIONS AND ACRONYMS

ITCZ - Inter-Tropical Convergence Zone

IGAD-ICPAC Intergovernmental Authority on Development-Climate Prediction Application Center

IPCC Intergovernmental Panel on Climate change

GDP Gross domestic product

GHGs Green house gases

FAO Food and Agriculture Organization of the United Nations

UBOS Uganda Bureau of Statistics

CO_2 Carbon dioxide

CH4 Methane

SRS Simple Random sampling

ABSTRACT

Climate change poses a significant threat to our planet, causing natural disasters and affecting the environment, agriculture, economy, and society. This study assessed the impact of climate variability on the socioeconomic livelihood of Arapai Division. Arapai Division is in Soroti City, Teso Sub-region, in Eastern Uganda. The division has a tropical wet and dry, or savanna, climate. The study engaged both qualitative and quantitative methods to collect data. This included the administration of questionnaires, face-to-face interviews, and focus group discussions. The data was collected from 396 respondents and analyzed using Chi-square, correlations, descriptive and Regression also focus group data was analyzed using content analysis. The study revealed that climate variability has a detrimental effect on livelihood, food security, health systems, and labor productivity. The study found out that the people were aware of climate variability and its major events of concern were floods and droughts, which affected crop yields, a major source of livelihood. 13% of people's health was impacted by climate variability, with 36.7% recognizing crop diversification as a coping strategy. Based on the findings, the study recommends strengthening of the agricultural sector, diversifying livelihood options, improving health systems, and introducing climate-resilient policies. The study advocates that future research should look into the types of livelihoods that would be most effective and sustainable for the residents of Arapai Soroti.

CHAPTER ONE

INTRODUCTION

1.0 Background to the study

Human actions are swiftly altering the global climate at rates that are unprecedented in history. Climate change on a global scale is one of the most important problems facing the world today. The majority of socioeconomic sectors, including agriculture, water, health, transportation, and energy, are all impacted by extreme events that are linked to weather and climate fluctuations. Research has shown that climate change and agriculture are two interrelated phenomena that cannot be separated and that their interplay has had a detrimental effect on agricultural productivity and livelihood (Atube *et al*., 2021).

Climate has a significant impact on agriculture since crop productivity is influenced by weather, and temperature affects both plant development and growth. Despite making a significant contribution to the economy overall, it has faced frequent and significant problems from a variety of sources. Examples include climate-related disasters like floods and droughts, which are particularly severe ones. Global climate variability and change always negatively affect the agricultural sector, and the situations are projected to get worse over time and vary across countries and regions, affecting communities that depend on agriculture as a source of livelihood, especially in underdeveloped and deprived nations. Additionally, the effects of climate change may hinder economic progress (Chambwera and Stage, 2010; Ochieng *et al*., 2016; Schilling *et al*., 2020).

In addition to agriculture producing 30–34% of the world's food supply in terms of calories, smallholder farmers are the most susceptible to the effects of climate change. Nine out of ten households in rural communities in sub-Saharan Africa also rely heavily on agriculture for their livelihoods. Because of the loss in food production caused by crop failure and the rise in disease and livestock mortality rates, climate variability poses a danger to livelihoods, agriculture, and food security. It is crucial to think about how to

make livelihoods resilient to the effects of global climate variability since these programs need to be able to manage and adapt in order to maintain environmental, economic, and political sustainability (Davis *et al*., 2017; Gottert *et al*., 2020; Mehdi *et al*., 2021).
It is necessary for pastoralists and agro-pastoralists to adapt to changes in water regimes in order to maintain food security and well-being because severe droughts in Sub-Saharan Africa have made it difficult for people to raise crops and cattle. The poor, largely subsistence-based rural people of Africa are particularly sensitive to and negatively impacted by the effects of climate change since they rely only on natural resources to make a living. They need coping mechanisms and techniques to deal with the disruptions to their lives caused by the consequences of climate change because of the inadequacy of resources combined with intrinsic poverty-related issues. (Ashby & Pachico, 2012; Gitz *et al*., 2016; McKinney & Wright, 2021)

Climate change refers to a progressive rise in the average temperature of the earth's atmosphere and is typically related to global warming. Temperature increases on an ongoing basis have been characterized as global warming. Because of the worldwide increase in temperature, climate change is sometimes referred to as global warming. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, published in 2007, the growth in greenhouse gas emissions has caused an increase in average temperatures of 0.74 since 1901, which has contributed to global warming. Clearly, the United States Environmental Protection Agency (2014) affirmed that carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) are the most harmful greenhouse gases. As a result, stakeholders are now aware that climate change is a fact. Additionally, there is mounting evidence that climate change poses a serious threat, particularly to developing and underdeveloped nations (Singh and Purohit, 2014).

It is evident that agriculture provides a means of subsistence for the majority of people in developing countries, as it provides jobs, income, and benefits to the rural population directly or indirectly. Due to this, agriculture remains the primary source of income and upkeep for the majority of people living in rural communities in underdeveloped countries in Africa (FAO, 2003), an evaluation that is equally validated by Kydd and

Dorward (2001) and according to studies, the majority of the world's poor resides in rural areas and support themselves by farming, gardening, or other jobs associated with agriculture. Accordingly, other studies also claimed that the impacts of global climate change are well recognized as being severe, particularly in countries in tropical Africa that depend heavily on agriculture for their primary means of subsistence.

According to IGAD-ICPAC (2007) by the year 2030, the average annual temperature throughout Eastern African nations is predicted to climb by 0.9 to 1.1°C. Due to Uganda's location across the equator, the Inter-Tropical Convergence Zone (ITCZ), monsoonal winds, subtropical anticyclones, large water bodies, topography, moist westerly winds from the Congo basin, and human activities are some of the factors that influence the country's climate (temperature and rainfall). These causes provide a wide range of rainfall in the country, with some places seeing high precipitation while others suffer from it. Climate variation has affected the routine influence of these factors and has changed their regular incidences. Areas around Lake Kyoga Basin receive mean annual rainfall ranging from about 800 mm in the northern cattle corridor to about 2050 mm in Mount Elgon.

Instances of weather-related events in Uganda, such as extended dry seasons, floods, storms, mudslides, extreme rainfall, and delayed or early rains, have become more frequent and/or intense. These extreme weather occurrences disturb the stability of people's livelihoods as well as access and food production. These conditions leave most of the poor rural farmers' food insecure and their livelihoods threatened, and these are signs of change in the climate in the last 10 years (Okonya *et al*., 2013). And related economic losses for example, drought conditions in 2010/11 caused economic losses of US$470 million in food crops, cash crops, and livestock. This compared to about 16% of the total yearly value of these crops in 2011.

Soroti city is found in eastern Uganda and is a semi-arid area with warmer temperatures**;** its temperatures are 1.93% higher than Uganda's average, and the expected rise in temperatures from normal will increase crop heat stress and evapo-transpiration needs in the region, according to previous reports on climate change in the sub-region that Teso published. Sub-region Soroti, inclusive, is experiencing climate change cases of extreme

events such as highly erratic rainfall, droughts, and floods, and increasing and decreasing trends in temperature and precipitation have been recorded. The sub-region has already been affected by frequent floods and droughts that have caused loss of property and fatalities, and these changes are expected to exacerbate and affect natural resources like water and air, which are thought to be the most important factors related to climate variability. This calls for additional research for a better understanding and level of support. Thus, it is evident that there is a rising need in Arapai sub-county, Soroti City, to understand how climate change is having an influence on communities and how it affects people's livelihoods. There is also a need for adaptation and mitigation methods, as well as local adaptation techniques. This is the basis for the present study.

1.1 Statement of the problem

Natural ecosystems and human livelihoods are being destroyed by climate change, a serious worldwide hazard. Africa, in particular (Uganda, especially Soroti City, is not an exception), is consequently susceptible to climate change because of its stagnating economic development, which has left it with little ability to respond to its impacts.

The Teso sub-region is one of the most affected areas in the country because it is socially and economically underdeveloped, has poor infrastructure, has high rates of biodiversity and natural resource loss, and is vulnerable to drought and floods, which may lead to poor agricultural production and cause famine, malnutrition, and other problems. The area is also more susceptible to climate change because its temperatures are a little higher than those of the nation as a whole. The existing literature, e.g., Egeru *et al*. (2019) shows that there is little scientific knowledge on the impacts of climate change on socioeconomic livelihoods in Arapai Division, especially where socioeconomic livelihoods are negatively impacted by climate change, which results in socio-economic problems like hunger, poverty, low income, low food production, and unemployment. Literature showed that Arapai division of Soroti has been affected regularly in the past by negative consequences of climate variability and change (Egeru *et.al*. 2019, USAID, 2015).Thus, this study was carried out to examine the impacts of climate change on socioeconomic livelihood in Arapai Division.

1.2 General objective

The general objective of this study was to determine the impact of climate variability on socioeconomic livelihoods in Arapai Division, Soroti City.

1.3 Specific objectives were to:

i. Determine the implication of climate variability on livelihoods in Arapai Division, Soroti City.
ii. Identify the impact of climate variability on human health in Arapai Division, Soroti city.
iii. Establish the coping strategies of local farmers against impact of climate variability in Arapai Division, Soroti City.

1.4 Research questions

i. What is the implication of climate variability on livelihoods in Arapai Division, Soroti City?
ii. How has climate variability affected human health in Arapai Division and Sororti City?
iii. What are the coping strategies used by local farmers in Arapai to mitigate the impacts of climate variability on local farmers 'livelihood?

1.5 Scope of the study

1.5.1 Content scope

Generally, the goal of the study was to determine how climate change has affected the socioeconomic situation in Arapai Division, a community in the Soroti City of eastern Uganda. The researcher chose to use Arapai Division in the Soroti City as a case study, which was justified because Soroti is not immune to the detrimental effects of climate change on the livelihoods of rural communities in Uganda. Soroti has already documented cases of climate change with negative effects including drought, famine, floods, prolonged dry spells, and dust storms, among several others, and climate-stimulated reductions in crop yields, making food security a challenge. The study was limited to the local people (respondents) such as community leaders, agricultural

extension officers, environment officers, and natural resources officers of Arapai Division to establish their views on the impact of climate variability on their livelihoods. The respondents were selected from three parishes using simple random and purposive sampling techniques.

1.6.2 Geographical scope

Geographically, Arapai Division is a settlement in eastern Uganda. It is a village in the Soroti City Teso sub-region, and it is located at an elevation of 1133.09 meters above sea level. Arapai has a tropical wet and dry or savanna climate.

1.6.3 Theoretical scope

The study was based on the theory of human forcing, which explains the relationship between climate and human activities and how human transformation of the natural world affects the climate, which later impacts human activities and livelihoods that are reliant on climate (Pielke *et al*., 2009).1.6.4 Time Scope

The study took place over a period of about six (6) months, from November 2022 to April 2023, in the academic year 2022–2023.

1.7 Significance of the study

This study was designed to determine the impact of climate variability on the socioeconomic livelihood of the residents of Arapai Division, Soroti city, and the research findings shall be beneficial.

1. To rural communities in the study area to empower them to have a better comprehension of the defining attributes of climate variability and livelihood.
2. In the development of policies and adaptation strategies by the local communities, leaders, and NGOs
3. Foster further research by building on the knowledge base and making information available for future researchers.

1.8 Definition of Key Terms

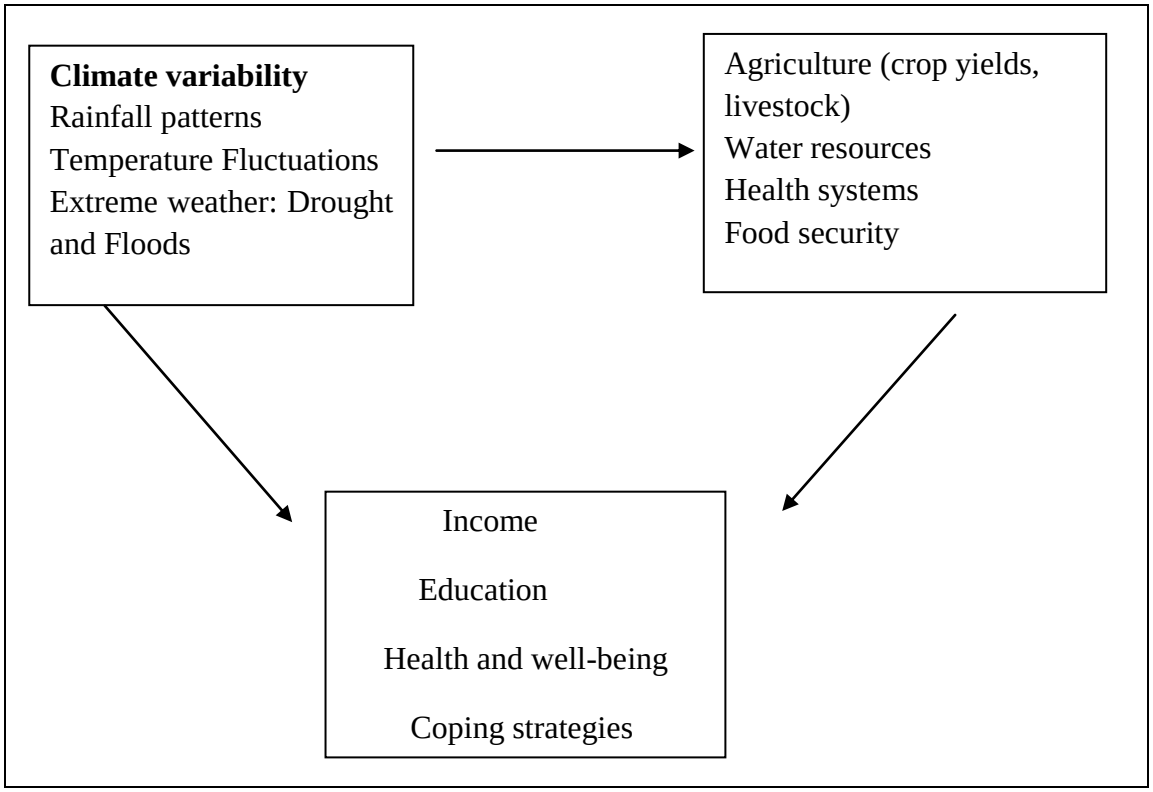
The following terms have been defined as operationalized in this study as perceived by the researcher:

Climate change is any variation in climate over time, whether due to natural variability or as a result of human activities.

Socioeconomic status refers to an individual's or family's social and economic position within society.

Livelihoods entail various activities, resources and assets that people rely on to earn a living and support themselves and families.

1.9 Conceptual framework



Source: Oduniyi (2017)

The conceptual framework explains how climate change and variability impact livelihoods, which result in adaptation options. Adaptation options aid in reducing and coping with the effects of climate change, as well as increasing livelihood among communities. Climate change impacts livelihoods, socio-economic characteristics,

policies, institutions, and adaptation measures, enhancing outcomes by addressing climate change.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

In this chapter, relevant literature related to the impacts of climate change on socio-economic conditions is reviewed. The review is guided by three questions, namely: (i) what are the implications of climate variability on socioeconomic livelihoods in Arapai Division, Soroti city; (ii) how has the climate variability affected human health in Arapai Division, Soroti city; and (iii) what is the implication of climate variability on local farmers in Arapai Division, Soroti city. The review will be followed by a summary presenting the gaps identified from the literature review.

2.1 Conceptual review

Due to human activity, the world's climate is changing at a rate that is unprecedented in human history. The majority of socioeconomic sectors, including water, transportation, agriculture, health, and energy, are impacted by changing weather and climate with extreme events (IPCC, 2007b) (Nagy *et al*., 2018). Climate shows the characteristics of the atmosphere at a given location on the lower surface of the earth, whereas climate variability refers to long-term changes in average weather patterns. The main contributor to the current global warming is the buildup of CO2 and other greenhouse gases in the atmosphere, which are linked to greenhouse gases and climate change. Solar heat is absorbed and held in the air by greenhouse gases. As greenhouse gases build up in the atmosphere, more heat is trapped and the temperature of the Earth rises (Oelbermann & E., 2011).

Climate change is globally affecting sources of livelihoods among rural people, where their capacity to cope cannot be guaranteed as sure solutions (Fadairo *et al*., 2020). Extreme occurrences deplete the resources needed for development, which places a tremendous strain on people and communities. In addition, climate change will create new opportunities for human progress (Ding *et al*., 2021; Streimikiene *et al*., 2020). The negative effects of extreme weather events have cascading effects on societies, which are made up of individuals, groups, and institutions or organizations. Examples include the social implications of flooding, heat islands, and drought on people and infrastructures (Ding *et al*., 2021; Judith, 2022). Due to its negative effects on agriculture, health, the environment, roads, and structures that are sources of livelihoods in particular in developing nations, climate change poses a threat to undo decades of development efforts (Connolly-Boutin & Smit, 2016).

The negative effects of climate change on society's economic systems, such as decreased agricultural output, imbalances in energy supply and demand, and modifications to integrated commerce networks, all of which have a negative influence on economic growth (Weindl *et al*., 2010; Lu *et al*., 2019). The velocity and intensity of climate change and the rate of extreme weather events may result in a concurrent net wearing down of society's and individuals' resiliency as well as instability in social resistance and recovery (Nagy *et al*., 2018). The repercussions of climate change are inevitable, and rural areas that depend on agriculture for a living are particularly vulnerable to its effects (IPCC, 2007b). Because agricultural yields depend on weather conditions and temperature has an impact on crop growth and development, agriculture is particularly vulnerable to fluctuations in the average temperature. Despite the fact that agriculture is the primary source of livelihood for 2.5 billion people worldwide and accounts for 26% of GDP (gross domestic product) in the economies of various low-income developing countries, climate change poses a threat to agriculture and food security due to the loss in food production through crop failure and the increase in disease and livestock mortality rates (Schilling *et al*., 2020). Adverse consequences of temperature on GDP, poverty, and some other economies Wide outcomes such as the increase in morbidity and mortality, health insults on early life, social interactions comprised of the changes in terms and

cases of violence and hostility, even worse collapses and malfunctions of states and institutions, and demographic outcomes on migration and equilibrium demographic structure are typical examples (Ding *et al.*, 2021).

Climate dynamics also pose a hazard to public health, as seen by incidences of undernourishment, cardiovascular disease, respiratory disease, harmful algal blooms, etc. (Watts *et al.*, 2015). Health is the foundation of human capital, which, along with other resources like natural capital, determines the standard of living. Eventually, this affects the economy, which in turn influences public health and livelihoods (Dang *et al*., 2020; Reed *et al*., 2013). In general, the level of social development is determined by livelihoods, public health, and economics, which is made up of many industries.

Uganda is experiencing weather-related events such as extended dry spells, storms, floods, mudslides, severe rainfall, and delayed or early rains that have become recurrent and/or intense, leaving livelihoods threatened and many rural poor farmers' food insecure. Due to its high reliance on rain-fed agriculture for both economic development and essential food security, as well as its pervasive poverty, sub-Saharan Africa is perhaps the region most vulnerable to various adverse effects of climate dynamics. Over the past 35 years, the Karamoja region has seen average monthly temperature increases and an increase in rainfall variability (Egeru *et al*., 2019). Increased frequency, severity, and duration of heat waves, as well as decreased water availability, would directly affect households. Additionally, rising temperatures will negatively impact the region's livestock and agricultural productivity, further escalating the issue of food insecurity (McKinney & Wright, 2021).

2.2 Theoretical review

According to the Human Forces Theory, human activities that alter the surface of the earth by removing forests, irrigating deserts, and developing cities have a greater impact on the climate than greenhouse gas emissions.

Although there is little doubt that the natural causes of climate fluctuations and changes play a substantial role, human influences are also considerable and entail a wide variety

of first-order climate forcings, such as but not limited to the human emissions of carbon dioxide (CO_2) (Schilling *et al*., 2020).

Human forcing's theory explains the correlation between climate and human activities and how human interventions affect the natural world and the climate systems that later affect human activities and livelihoods that are contingent on climate. It is acknowledged that humans play a significant role in affecting environmental variability and change, particularly their impact on the climate system. Anthropogenic climate drivers such as emissions of heat-trapping gases, often known as greenhouse gases, and changes in land use, coastal development, and deforestation like affect how much sunlight the land reflects. (Olaore, A.Y., & Aja, 2014) Their contribution to changing the characteristics of air and ocean circulation away from what they would be in the natural climate system is one of their consequences [NRC, 2005]. Similar to CO2, their effects on the climate are thought to last for several decadal timescales or longer. Therefore, assessments for reducing CO2 and other greenhouse gases must be taken into account along with other human climate factors. In the upcoming decades, the most, if not all, of these human influences on regional and global climate will continue to be of concern. Altering the climate systems affects all spheres of planet Earth, thereby affecting livelihoods, and these calls for further studies to draw measures to address the impacts of climate change on livelihoods and natural systems.

2.3 Implications of climate change on socioeconomic livelihoods

Rural households' livelihoods are susceptible to changes in the weather and climate, which results in inadequate rural livelihood capital. The temperature is rising and the weather is getting warmer all the time, yet there isn't much rain falling (Majaliwa & Isubikalu, 2010). Climate change poses a serious environmental risk to agricultural production since it negatively affects farmers' ability to make a living because of its effects on agricultural productivity (Oduniyi, 2018). Almost all agricultural sectors are influenced by weather and climate, and these variables' volatility has caused rural farmers to experience interruptions in their farming operations due to the effects of climate change (Atube *et al*., 2021).

Climate change will exacerbate threats to livelihoods and food security due to a number of factors, including an increase in the frequency and severity of climate risks, decreased agricultural yields and production, worsening sanitation and health risks, a worsening water shortage, and growing conflict over insufficient resources. Due to the effects of climatic change on food insecurity, there will be new humanitarian crises and an increase in the number of displaced people (Gitz *et al*., 2016; Okonya *et al*., 2013).

Due to the interaction of biophysical, political, and socioeconomic stresses that increase the region's vulnerability and constrict its capacity for adaptation to climate change, the region of Sub-Saharan Africa will be negatively impacted in a number of ways, including food security and livelihoods (Connolly-Boutin & Smit, 2016). Uganda is one of the most susceptible countries to climate change effects because of the vulnerability of its national economics to the impacts of climate change on agriculture (UBOS, 2018). Climate change is broadly supposed to reduce crop yields and livestock productivity; its effects on food production and availability as well as the impacts of extreme climate events affect both physical and economic accessibility (Rahaman *et al*., 2020).

Climate change is increasingly affecting freshwater, marine, and terrestrial ecosystems and ecosystem services, water and food security, infrastructure and settlements, health and well-being, and culture and economies, mostly through compound stresses and incidents (Mehdi *et al*., 2021). Regional rises in temperature, drought, and aridity have amplified the incidence and intensity of fires. The relations between fire, land use change, mostly deforestation, and climate change are directly affecting human health, forest structure, ecosystem functioning, food security, and the livelihoods of resource-reliant societies (G. Oyarzun Manuel *et al*., 2021).

Climate change effects have been witnessed across economic sectors, though the amount of the harm differs by sector and is peculiar to regions. Recent severe weather and climate-induced incidents have been linked to large costs through damaged infrastructure, property, and supply chain interferences, although growth patterns have brought many of these enhancements (Fadairo *et al*., 2020). Adverse effects on economic expansion have

been recognized from extreme weather incidents with great consequences in developing countries. Widespread impacts of climate change have damaged economic livelihoods, particularly amongst defenseless populations. Climate effects and anticipated hazards have been inadequately internalized into private- and public-sector planning and accounting practices and adaptation finance (Nagy *et al*., 2018).

Economic declines due to climate change result from negative impacts on inputs, such as crop yields, availability of water, and outdoor labor productivity due to heat stress. Larger economic losses are viewed for sectors with elevated exposure to direct climatic conditions, as well as regional losses to agriculture, fisheries, forestry, energy, and tourism. Several industrial and examination sectors are not directly impacted by supply interferences, mainly during and following extreme events (Birara *et al*., 2015). Costs incurred from disaster spending, adaptation, revitalization, and reconstruction of infrastructure. Approximations of the universal consequences of changes in climate on combined gauges of economic performance and gross domestic product (GDP) vary from negative to positive, partly owing to insecurity in how weather inconsistency and climate impacts appear in GDP (Oelbermann, 2011).

Extreme weather occurrences, for instance, drought, tropical cyclones, and severe fluvial floods, have temporarily lessened economic growth and will continue to do so in the coming decades in both developing and developed countries. Development patterns have increased the exposure of more assets to extreme risks, increasing the extent of the losses. Wildfires partly attributed to climate change have caused substantial economic damages (Kusangaya *et al*., 2014).

Economic livelihoods that are more climate-sensitive have been excessively destroyed by climate change. Climate-sensitive livelihoods are more concentrated in areas that have elevated socioeconomic vulnerabilities and lower adaptive capacities, exacerbating existing inequalities. Extreme events have also had more prominent unfavorable effects in poorer areas and on more susceptible populations. These greater economic consequences have further reduced the capacity of these populations to get used to

existing impacts. Within populations, the poor, women, children, elderly, and native populations have been particularly susceptible owing to a mixture of factors, as well as gendered divisions of paid and/or unpaid labor (Oelbermann, 2011).

In Uganda, climate change impacts have activated an increase in agricultural produce prices (food and feed), which affect the economic and social position of the entire population, mainly in countries where a significant fraction of the domestic account is used up on food (Okonya *et al*., 2013a). This causes macro-economic results for agriculture-reliant countries for which agriculture is a main factor of GDP and/or for which agriculture comprises a vital part of employment. Climatic threats can also be capable of hampering agricultural growth by depressing ventures. Climatic distresses that have an effect on an important amount of global production or an area of significance in terms of global markets have universal effects on markets (Tol, 2018). These effects can be anticipated to become known over time with the evolution of climate change effects, in addition to fluctuations across different places and segments of the population. We should consider the results of amplifying amounts and occurrences of severe events and weather irregularities at hand and the upcoming plus longer-term effects linked with main changes in global warming.

Livelihoods are dependent on all assets, including human capital, social capital, natural capital, physical capital, and financial assets. Adaptation includes activities like reducing poverty, enhancing access to resources, reducing wealth and resource disparities, advancing education, infrastructure, institutional capacity, and efficiency, and preserving local indigenous knowledge (Thakur & Bajagain, 2019). It is apparent that climate change will have a significant influence on rural residents' access to water, infrastructure, food security, and revenue from agriculture (Ding *et al*., 2021). Since climate change causes hazards that collectively lead to extended poverty and persistent inequality in society, poverty and inequality are pertinent conversation topics. The availability of food impacts the nutritional state of the human population, and inadequate nutrition has an impact on how well the body and mind function (Majaliwa & Isubikalu, 2010).

Numerous hazardous events brought on by climate change have a negative impact on patterns of livelihood. Floods and cyclones, in particular, have increased in frequency and severity, making it more challenging for the local population to safeguard their way of life (Thakur & Bajagain, 2019). The amount and timing of rainfall are both getting more attention in current studies. People are severely impacted by floods and cyclones, although other shocks, including drought, salinity intrusion, heat waves, cold waves, and fog, have low to moderate effects (Nagy *et al*., 2018). The less fortunate may lose their means of subsistence as a result. Additionally, repeated cyclone warnings caused people to spend more time at home and earn less money, which increased their poverty level (McKinney & Wright, 2021).

Weather-related human property destruction, such as undernourishment and chronic hunger brought on by failed crops or rising food prices, primarily affects the impoverished urban population (Flood, 2012). Schools, offices, and service centers are all immediately impacted by climate-stimulated consequences and calamities, including hurricanes, irregular rainfall, rising river levels, shocks from cold waves, and sweltering heat. Thus, human health is affected in terms of education, access to services, and market operation, among other things (Gitz *et al*., 2016). It is thought that climate change affects both men and women differently; in some circumstances, it puts women in greater danger and hardship. Both the long-term and short-term effects of climate change can be linked to drought and a declining water table. People expressed worries about the present spring's sources of drinking water drying up and the difficulty of transporting water from the new source (Ashby & Pachico, 2012).

The effects of climate change on society and social assets are varied. For example, community forest users, group committees, school developments committees, temples, youth clubs, and cooperatives are hindered by various events and must change their usual settings, reschedule meetings, and create conflict due to resource and workload constraints for forest management, fire control, and invasive species clearance (Shrestha *et al*., 2012).

Natural occurrences like extended rainstorms, cold waves, or heat waves can separate people from social gatherings. In a similar vein, climate change events have detrimental consequences on both production and services, which could result in deficits, price increases, shortages, and unequal distribution, endangering social cohesion and allegedly increasing forced migration of marginalized groups (Evans, 2009).

In eastern Uganda, where there has been an increase of about 1500 mm in precipitation during the December to January rainy season, high rainfall conditions have been commonplace since 2000 (NEMA, 2008). The Teso region, which includes Soroti City, has been particularly negatively affected by these trends. The sub-region in the country's northeast has witnessed a number of significant floods since 2004, which have been sporadically followed by protracted droughts. Planting plans in the sub-region have essentially been derailed as a result. In Texas, the 2007 flood was the worst ever. Another flood struck the Teso region in September 2010, resulting in decaying groundnuts, cassava, and sweet potato tubers (GoU 2012: 13), the 2012 floods, and the 2014-2015 droughts (El Nio). Following a protracted drought, the notion of long-term climate change as opposed to just climate variation became widespread among the locals in Soroti. These weather events are thought to have been more devastating than any previous recent catastrophes in terms of severity, and as a result of them, the area experienced hunger (Friis-Hansen *et al.*, 2015). By analyzing the effects of climate change on rural livelihood in the Arapai, this study seeks to close the gap that has been identified. It also adds to the body of knowledge by developing policy measures, agricultural practices, and potential alternate sources of rural livelihood. Therefore, it is important for this study to be carried out to establish the socioeconomic effects of climate change and draw possible measures that may be useful to rural communities and policymakers.

2.4 Climate variability on human health

Human wellbeing is a wide notion that encompasses parts of biophysical health services like clean air, safe and sufficient water supplies, and a global ecosystem that will continue to provide these services on an individual level (Akinsete *et al*., 2019). According to the World Health Organization, health is "a condition of complete mental, social, and physical wellbeing and does not just refer to the absence of sickness or disability." These biophysical wellbeing services are strongly related to both the concept of life support systems and environmental wellbeing (Nagy *et al*., 2018).

Between 2030 and 2050, it is predicted that global climate change will result in roughly 250,000 deaths annually from malaria, diarrhea, starvation, and heat stress. Therefore, in the future, a decrease in public spending on health and social care may worsen changes in health outcomes linked to climate change, making the region the most vulnerable location for health outcomes (Nagy *et al*., 2018). Climate variability has deteriorated the bodily and mental health of people. In all regions, health effects regularly damage endeavors for general growth. The elderly, women, children, Native People, underprivileged households, and socially marginalized groups within settlements, cities, regions, and countries are the most vulnerable (Ding *et al*., 2021). Indigenous people are identified as being at a higher risk and are experiencing significant differences in health burden. Locals in sub-Saharan Africa have worse health outcomes than average, a lower social standing, and are more sensitive to environmental change because of their reliance on natural resources and traditional healthcare systems (Ogallo, 2014; Zhong and Huang, 2019).

In the past ten years, it has been noted that the mortality rate from floods, droughts, and storms is higher in fragile countries than in less susceptible ones. While droughts have increased to varying degrees on practically all continents, they mostly affect the most vulnerable areas and cause a disproportionately high fatality rate. Drought caused 34% of disaster-related deaths between 1970 and 2019, predominantly in Africa, although it accounted for only 7% of all catastrophe events globally (Gitz *et al*., 2016).

Due to its underdeveloped economy and poor access to healthcare, Uganda is particularly vulnerable to the negative health effects of climate change. While it is challenging to predict how climate change may manifest in Uganda due to the lack of local and national scientific monitoring and knowledge (Oyarzun Manuel *et al*., 2021). Due to the fact that more than 80% of Uganda's population depends on rain-fed agriculture for a living, these ecological changes will have an influence on economic welfare, which in turn will compound potential health implications (World Bank, 2011; Kabugo, Rancoli, & Majugu, 2010). Public health concerns now include diarrhea, waterborne illnesses, and malaria, which are on the rise due to inadequate sanitation, poor hygiene, and decreasing food security (Gjorgievski *et al*., 2022; Wandiga *et al*., 2010).

The problems with psychological health are exacerbated by rising temperatures, the trauma of extreme weather, and the loss of culture and livelihoods. Climate-related ecological grief associated with environmental changes (such as solastalgia), severe weather and climate events, shocking experiences or expectations of climate events, and climate-related loss of livelihoods and food insecurity have all been linked to distress that is severe enough to harm mental health (Nkosi *et al*., 2021). There is evidence that certain groups of people are more vulnerable to the psychological health effects of climate change than others, including Native Americans, agricultural communities, first responders, women, and members of marginalized groups.

Climate change has led to malnutrition in all its forms in various regions, together with under nutrition, over nutrition, and obesity, and to disease vulnerability, particularly for women, pregnant women, children, low-income households, local people, marginal groups, and small-scale farmers. Severe climate events have been major drivers of the rising under nutrition of millions of people, primarily in Africa and Central America. Such as, anthropogenic warming led to climate incidences induced by the 2015–2016 El-Nio, which caused severe droughts, leading to an additional 5.9 million children in 51 countries becoming underweight. Under-nutrition can in turn amplify vulnerability to other health problems, as well as psychological health problems, and damage cognitive

and work performance, with resulting economic impacts. Negative effects on diet and health are disproportionately experienced by children and expectant mothers.

Although climate variability is not always the primary factor, a number of chronic, non-communicable respiratory disorders are climate-responsive depending on their exposure pathways (such as cold, heat, dust, tiny particles, ozone, fire smoke, and allergens). In certain areas, exposure to wildfires and their associated smoke has increased. The 2019–2020 southeastern Australian wildfires resulted in 33 fatalities, 429 additional fatalities, 3230 hospitalizations due to cardiovascular or respiratory conditions, and $1.95 billion in medical expenses.

The most seriously affected nations are those with poor health status and minimal capacity for adaptation (Fussel, 2010). Sub-Saharan Africa has been acknowledged as one of the world's most vulnerable areas (Ramin & McMichael, 2009). People have reported suffering from poor effects on their mental health, physical health, and social relationships as a direct result of severe weather events linked to climate change, including hurricanes, heat waves, flooding, droughts, and wildfires (Oyarzun Manuel *et al*., 2021) these are significant because of their potential to have an effect. The gradual shifts in average temperature, sea level, and rainfall patterns that will define our climate in the coming decades are those that will affect more people (Oyarzun Manuel *et al*., 2021).

Interruptions to the economic, social, and physical systems are important contributors to psychological health and exacerbate established risk factors for mental diseases (Obradovich *et al*., 2018). Mental health issues are already prevalent and costly. Nearly half of all Americans will experience mental illness at some point in their lives, with the majority of diagnoses being anxiety, stress-related, and anger problems (Oyarzun Manuel *et al*., 2021; Obradovich *et al*., 2018). Mental disorders exacerbate general health, lessen productivity, and decrease quality of life (Obradovich *et al*., 2018). Distress can damage psychological and immunological functioning, lessening the capacity to survive with difficulty.

Heat, the accelerated spread of water-borne and vector-borne diseases, natural catastrophes, and undernourishment, in addition to the acute socially mediated effects of forced migration, conflicts, and calamities, will be hazardous to physical health (Goyal & Surampalli, 2018). Some assemblies are mainly defenseless due to greater contact, a shortage of economic and political power, or physical factors such as native people, the elderly, children, and in some cases, people with pre-existing health problems.

Children may undergo the toughest effects because they are more exposed to the consequences of direct experience with climate change (Birara *et al*., 2015). On a regular basis, they contain stronger reactions to severe weather incidents, such as PTSD, sleep disorders, depression, et cetera, partially owing to their increased reliance on family members who are adults and on social networks that could be upset by the event (Bartlett, 2008). They are as well more exposed to heat owing to their bodies' partly developed ability to thermoregulate (Zivin & Shrader, 2016). The exact cause for concern is the probability of long-term and/or persistent effects of early emotional trauma, which can affect children's capability to regulate their emotions and result in academic or behavioral difficulties. Early-life stress might increase the risk of developing psychological health issues later in life (Burke, Sanson, & van Hoorn, 2018).

Climate variation is correlated with the amplified regularity and harshness of severe weather incidents and the implications of distinct occasions. For instance, decades of research have shown that the impact of natural catastrophes on psychological health has increased levels of anxiety, despair, domestic abuse, and even substance usage after storms (Morganstein & Ursano, 2020). For locals who have suffered greater suffering, the consequences often tend to be more severe, but they are tempered by factors like social support and adaptability. Natural disasters also have indirect effects on society's infrastructure, disrupting the financial, healthcare, transportation, and educational sectors. Increasing people's worry levels and endangering those in danger's mental health (Clayton *et al*., 2017; Manning & Clayton, 2018).

The Teso region experienced widespread floods in 2007, 2009/2010, and 2012 that devastated the region where malaria prevalence is currently unchanged. Population expansion will likewise increase the at-risk populations. Schistosomiasis, dengue, and cholera are among the vector- and water-borne diseases that are anticipated to rise as a result of flooding (Egeru *et al*., 2019).

2.5 Implications of climate variability on local farmers livelihoods

2.5.1 Climate change and agricultural production

Extreme weather events linked to the climate have a negative impact on forests, fisheries, and agricultural yields. Food is reduced by extreme occurrences like floods, droughts, oceanic heat waves, and wildfires. Food security, nutrition, and the livelihoods of millions of people across states are at risk due to limited availability and inflated food prices. Massive events result in losses in crop production, animal rearing, and forest production. The devastating effects of high heat and drought have led to the collapse of local fisheries and aquaculture. Extreme weather and climatic events put people at risk for food insecurity, which can cause malnutrition and increase the risk of disease (Okonya *et al*., 2013b). At least 30 people were killed in recent floods in eastern Uganda, and 400,000 were left without access to clean water. The floodwater around Mbale City at the foot of Mount Elgon cut off hundreds of thousands of people from accessing fresh water supplies, and sewage systems were destroyed, raising concerns about disease outbreaks. Water Aid predicts that there will be more instances of heavy rain in the future. About 5,600 people were left homeless as a result of this disaster in Mbale City alone, and 400,000 people have now lost access to the national water grid. The destruction of sewage infrastructure and sanitary amenities like latrines has polluted the environment. Furthermore, the destruction of 5,000 acres of crops could result in food shortages (Region *et al*., 2022).

A loss in soil organic matter and soil moisture, premature drying of grains, and higher heat stress are all negative effects of climate change that have a severe effect on agricultural productivity (Mekonnen *et al*., 2021). Food safety consequences of climate change have primarily been discovered in relation to agricultural production, and hence

food production (Cline, 2007) anticipates a 15.9% reduction in agricultural productivity globally, with a disproportionally greater 19.7% decline in underdeveloped nations. Similarly, a 2055 simulation of maize production in Latin America and Africa predicted a 10% overall drop (Jones & Thornton, 2003). Climate change could affect agriculture, bearing in mind its intense dependence on natural resources. When climate goes beyond the niche of crops, the production would be significantly impacted (Liu *et al*., 2020). Agriculture is a significant sector of most countries, mainly in terms of its contribution to the livelihood of the population, gross domestic product (GDP), and food safety. Generally, about 67% of the region's people rely on agriculture for their livelihood (FAO 2011). More particularly, for the three countries comprised in the current study, agriculture accounted for 15% of GDP. Climate change poses a significant risk to production in the Pacific Island nations' agriculture and fisheries sectors, as recognized by the Intergovernmental Panel on Climate Change Fourth Assessment Report.

2.5.2 Climate change and local farmers

As farmers mostly rely on rain-fed agriculture, climate is a key supplier for both animal and crop development in developing countries (Birara *et al*., 2015). Even with all other elements held constant, climate fluctuation can lower yield and make food less accessible, worsening household food insecurity (Jour *et al*., 2020). A growing consensus in the scientific community also demonstrates that climate change is causing changes in temperature, precipitation, and levels, all of which reduce crop yields in developing nations (Alemu & Mengistu, 2019). According to the Intergovernmental Panel on Climate Change's (IPCC, 2014a) predictions, the loss of 20–30% of plant and animal species is expected to have severe consequences for food safety in developing nations (FAO, 2007; IPCC, 2014a, 2014b) (Mekuriaw *et al*., 2014).

The conditions under which agricultural activities are carried out have been profoundly modified by climate change. Climatic variation has both indirect and direct effects on agricultural production. Direct effects include implications for specific agricultural production systems resulting from changes to physical characteristics like rainfall patterns and temperature ranges. Those effects that affect production indirectly include

those that have an impact on pests, disease vectors, invading species, and pollinators. Indirect effects may be important (Ramakrishna & Bang, 2014). Climatic change has a negative impact on maize and wheat yields in different regions as well as globally, according to studies on how climate trends affect crop productivity.

Everyone is impacted by climate change's effects on food systems, but some populations are more vulnerable than others, including the elderly, women, and children in low-income households, Indigenous Peoples, minority groups, small-scale farmer and fishermen communities, and people who live in high-threat areas, who frequently lose their livelihoods and suffer from malnutrition and rising costs (Ramakrishna & Bang, 2014). Increased pressure on scarce resources like land, energy, and water may worsen how negatively climate change is affecting food security. Large-scale land deals, water use, food habits, the use of feed crops, and energy crops are a few examples.

2.5.3 Climate change and food systems, food security, and forestry

With negative effects on human nutrition, food security, and way of life, particularly at low and mid-latitudes, climate variability is already impacting food and forestry systems. Climate change impacts are negatively disturbing agriculture, fisheries, forestry, and aquaculture, increasingly inhibiting attempts to meet human demands. This causes the global food system to fail to resolve malnutrition and food insecurity in an environmentally sustainable way. In low and middle latitudes, the rise in agricultural productivity during the preceding 50 years has been constrained by human-caused global warming. Surface ozone threatens crop productivity (Uganda Bureau of Statistics, 2018). Growing temperatures and surface ozone concentrations have negatively impacted crop yields as a result of methane production. Crop and grassland quality as well as harvest consistency are being significantly impacted by warming. In many temperate and boreal biomes, hotter and drier conditions have magnified tree mortality and forest disturbances, negatively reducing provisioning services. Between 1930 and 2010, ocean warming reduced certain wild fish populations' sustainable yields by 4.1%. Aquatic creatures raised for food have already been damaged by ocean acidification and warming (Kundzewicz *et al.*, 2018).

Temperature increases have changed the distribution, suitability of growing areas, and timing of major biological occurrences, such as flowering and pest invasion, which has an impact on food quality and harvest stability. There is high confidence that the distribution of wild terrestrial and domesticated marine and freshwater species is changing due to climate change. Temperatures have regularly exceeded upper tolerance thresholds, causing heat stress and/or changing the distribution of and/or causing losses to livestock, crops, fisheries, and aquaculture (Oelbermann & E., 2011).

All agricultural and fishing sectors have seen production declines as a result of climate-related events, which have had a negative impact on livelihoods and food security. Since at least the middle of the 20th century, both on land and at sea, the frequency of unexpected losses in food production has increased. People living in sub-Saharan Africa, Asia, tiny islands, Central and South America, the Arctic, and small-scale food producers worldwide are particularly acutely affected by the impacts of climate-linked extremes on nutrition, food security, and livelihoods (Connolly-Boutin & Smit, 2016). In many different places, including eastern and southern Africa and the Dry Corridor of Central America, the El Nio of 2015–2016 that brought drought also contributed to severe food shortages. The resilience of livestock keepers has decreased as a result of the unfavorable effects of increasing grazing system inconsistency on animal fertility, mortality, and herd revival rates.

Worldwide risks related to food insecurity in agriculture and fisheries are rising. Toxigenic fungi are amplified on many food crops by increased temperatures and humidity brought on by climatic changes. Water-borne illnesses and harmful algal blooms pose a threat to coastal communities' economies, livelihoods, and access to food (Mekonnen *et al.*, 2021). Ocean acidification and temperature rise speed up the movement and bioabsorption of poisons and pollutants into marine food webs, and persistent organic pollutants like methyl mercury are already having a negative impact on fisheries (G. Oyarzun Manuel *et al.*, 2021).

2.5.4 Climate variability on biodiversity and ecosystems

Terrestrial, marine, and freshwater ecosystems all around the world have been altered by climate fluctuations. Its effects were felt earlier and are more widespread, with wider-ranging results than anticipated. Biological responses, which might vary in growth, abundance, physiology, geography, and changing seasonal timing, are frequently insufficient to adapt to recent climate changes. Climate change has caused extinctions of native species, an increase in diseases and mass animal and plant deaths, the reformation of ecosystems, an increase in the number of regions burned by wildfires, and a decrease in essential ecosystem services (Shrestha *et al*., 2012). Climate-determined effects on ecosystems have resulted in considerable economic and livelihood losses and distorted cultural practices and recreational actions around the world.

Due to adaptation restrictions brought on by human-induced warming, there has been well-documented local population loss in the equatorial regions and lower boundaries of allocations, which has resulted in a variety of contractions. Local population extirpations, including the loss of land plants and animals, are most common in tropical ecosystems (55%), freshwater systems (74%), as well as terrestrial (46%), and marine (51%). Several mountaintop species have seen population declines at lower elevations, which has steadily reduced their range and increased their risk of extinction (Birara *et al*., 2015). Worldwide extinctions owing to climate modification are now being detected, with two extinctions at present characterized by anthropogenic climate transformation. Mass extinctions and climate-related extinctions are both common, highlighting the potential for climate change to have catastrophic impacts on species and ecosystems. (Oyarzun Manuel *et al*., 2021)

Ecosystem services connected to human health, livelihoods, and well-being are suffering from climate variability. Warming and drought, which are made worse by non-climatic human activities, are steadily limiting the services of carbon absorption provided by ecosystems on land that result from CO2 fertilization effects. Some locations have already transitioned from being carbon sinks to carbon sources due to deforestation, the burning and draining of peat bogs and tropical forests, and the melting of Arctic

permafrost. In many areas, the severity and extent of forest insect pest outbreaks increased. Invasive grasses in semiarid environments have increased the risk of fire, while woody plant development in grasslands and savannahs has reduced grazing land. Warming and CO2 fertilization have altered the biodiversity of coastal ecosystems, generating regionally varying carbon storage or discharge (Birara *et al*., 2015).

The loss of ecosystem functions, the replacement of endemic species, and regime shifts in seascapes and landscapes have a devastating impact on human societies, particularly indigenous peoples and those who rely primarily on natural resources for livelihood. Native knowledge holds exceptional information sources concerning the ancient changes and possible remedies to current issues (Yletyinen *et al*., 2020). There is a loss of both tangible and intangible assets, such as endemic knowledge and remarkable insights about plants and animals, carnivals and rites related to nature-based activities, traditional harvesting locations, and sites of species and cultural inheritance (Ogallo, 2014). Losses in biodiversity have a domino effect on local knowledge systems, health, food security, and livelihoods, frequently resulting in lasting harm and repercussions. Local plant and animal populations have seen widespread biodiversity losses, many of which have been connected to sharp increases in the hottest annual temperatures and heatwave events (Yletyinen *et al*., 2020).

2.5.6 Climate variability and water systems and water security

According to a preliminary estimate, the world's half of the population is reportedly suffering from a serious water shortage caused by climatic and other conditions. Climate-related water hazards and shortages are indicators of water insecurity, which is made worse by ineffective water governance (Rugumayo *et al*., 2015). Floods and droughts have a greater impact on society as a result of severe events and underlying vulnerabilities, which have also increased the incidence of water-borne diseases and negatively impacted agriculture and energy output. The effects of inadequate water supply on the economy and society are more severe in developing nations than in middle-income and industrialized nations (Brizee *et al*., 2019).

Climate change has intensified the world's hydrological cycle, resulting in a wide range of societal repercussions that are disproportionately suffered by the weak. Water-related vulnerabilities already present due to other socioeconomic issues have been made worse by human-stimulated climate variation, which has increased water shortages and increased people's vulnerability to strong water-related events like floods and droughts. Anthropogenic climate change is directly responsible for many of these changes in water availability and water-related dangers. The unavailability of water disproportionately affects the elderly, women, children, and people of color in developing nations and other marginalized areas (such as small island states and mountain regions). In places where there is inequality, poor water governance, and weak institutions, water scarcities can lead to social unrest. Variability in the hydrological cycle has impacted food and energy production and raised the incidence of water-borne illnesses. Both positive and negative effects on agricultural productivity have been caused by trends and extremes in the water cycle that are influenced by the climate, with negative effects outweighing favorable ones. Variability in rainfall, droughts, and floods have all led to decreased food availability and higher food costs, endangering millions of people's nutrition, food security, and livelihoods worldwide, particularly the impoverished in regions of Asia, Africa, and South and Central America. Drought years have reduced hydropower and thermoelectric production by about 4–5% compared to long-term average production since the 1980s, slowing economic growth in Africa and exposing it to greater risks. Increased prevalence of waterborne diseases like cholera is linked to variations in rainfall, temperature, and water-related disasters, especially in places with poor access to infrastructure for safe water, sanitation, and hygiene.

2.5.7 Climate variability on settlement

Involuntary migration and displacement are directly influenced by the dangers associated with climate change's extreme events and variability, and they are indirectly influenced by the failure of livelihoods that depend on a stable climate. The majority of climate-related migration and displacement occurs within national borders, with international migrations mostly occurring within nations with nearby borders (Arenilla & Rada, 2020).

Drought, hurricanes, tropical storms, torrential rain, and flooding are the main climatic factors that commonly cause migration and relocation. Involuntary migration and displacement are largely driven by extreme climate events, both directly (as in the case of tropical cyclones that destroy dwellings) and indirectly (as in the case of rural income losses during protracted droughts) (Obradovich et al., 2018).

People may be compelled to leave their ancestral homes due to a number of difficulties, such as sea level rise, melting glaciers, thawing permafrost, or deserts, all of which make it impractical to stay, and changes associated with a changing climate are predicted to increase both displacement and conflict (Islam & Khan, 2018; Arenilla & Rada, 2020). These relocations can be incredibly distressing, especially when they involve crossing boundaries. This is due to the uncertain nature of the crossing itself and the difficult process of adjusting to a new domicile, especially if visitors are not welcomed by the locals in new locations. Financial difficulties are typically a part of resettlement. This helps to explain why unintended refugees have a higher rate of psychiatric disease than other groups of migrants (Mindlis & Boffeta, 2017). Losing one's home because it's a vital source of support and flexibility can put one's mental health at risk (Tapsell & Tunstall, 2008). Conflicts in society over scarce ecological resources, such as clean, fertile land, enough water, or just enough room to build a home, can be another risk to people's mental health (Miller & Rasmussen, 2017).

Ecological variations also have important repercussions. Particularly, warming up has frequently been linked to antagonism and conflict (Miles-Novelo & Anderson, 2019), and more recently has been linked to a rise in the number of suicides and hospitalizations for mental illnesses (Carleton, 2017; Paulus & Rahwan, 2017). It is challenging to conclusively link heat waves to adverse effects on mental health, but decades of research in both field and lab settings have increased confidence that heat has a negative undercurrent shock on mental condition. More speculatively, mounting evidence suggests that poor air quality may have both immediate and long-term negative effects on mental health (Buoli *et al*., 2018). As a result of the burning of fossil fuels, which is likely to cause the production of pollutants such as particulate matter and carbon ozone, climate

change is projected to be accompanied by rising levels of air pollution. Higher concentrations of these contaminants also frequently remain in warmer air. Numerous scientific studies have proven a link between elevated levels of fine particulate matter (PM 2.5) and cognitive harm in the elderly or behavioral issues in children (Power *et al*. 2016; Yorifuji *et al*. 2017; Younan *et al*. 2018).

While Teso Region has occasionally experienced floods or droughts in the past (such as in 1972 and 1997), the climate situation has substantially deteriorated since 2007, and unpredictable weather has now become the norm. In 2007, 2009/2010, and 2012, the area including Arapai Soroti was ravaged by large-scale floods that damaged mud houses, roads, infrastructure, contaminated water sources, destroyed crops, and depleted food reserves, forcing many people to relocate temporarily. This study will establish the impacts on human health and develop possible solutions.

2.5.8 Coping strategies of farmers against climate variability

Recognition that climate change could have negative consequences for agricultural production has generated a desire to build resilience into agricultural systems. Crop diversification can improve resilience in a variety of ways: by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission, which may worsen under future climate scenarios, as well as by buffering crop production from the effects of greater climate variability and extreme events. Such benefits point toward the obvious value of adopting crop diversification to improve resilience, yet adoption has been slow. Economic incentives encouraging production of a select few crops, the push for biotechnology strategies, and the belief that monocultures are more productive than diversified systems have been hindrances in promoting this strategy

Current knowledge suggests that climate change will affect both biotic (pest, pathogens) and abiotic (solar radiation, water, temperature) factors in crop systems, threatening crop sustainability and production. More diverse agroecosystems with a broader range of traits and functions will be better able to perform under changing environmental conditions

(Matson *et al*. 1997, Altieri 1999), which is important given the expected changes to biotic and abiotic conditions. The following are a few of the major ways that the greater functional capacity of diverse agroecosystems has been found to protect crop productivity against environmental change. Farmers may be able to assist in creating biotic barriers against new pests by increasing the plant diversity of their farms in ways that promote natural enemy abundance. The composition of the plant community, as determined by a farmer, may be described as the planned diversity of the system. Crop diversity is critical not only in terms of production but also because it is an important determinant of the total biodiversity in the system (Matson *et al*. 1997). With greater plant species richness and diversity in spatial and temporal distribution of crops, diversified agroecosystems mimic more natural systems and are therefore able to maintain a greater diversity of animal species, many of which are natural enemies of crop pests (Altieri 1999). Many examples of pest suppression have been shown within agricultural systems possessing diversity and complexity, especially in comparison with less-complex systems (Cannon 1998**).**

2.6 Research gaps

Despite the literature on climate studies available on Eastern Uganda, there has been limited research works on climate variability and socioeconomic studies at present on the Arapai Division in Soroti. Therefore, with increasing drift of people towards the Eastern region of Uganda and recurrent negative consequences of changing climate recorded in previous literature, there is need to examine the implications of climate change on the socioeconomic livelihood of the Arapai division.

CHAPTER THREE : METHODOLOGY

3.1 Introduction

This chapter describes the methodological approaches that were followed during the study. The chapter depicts the study area, size, and location on the map, and the population. It also explains the sampling techniques, data collection, and data analysis to address the study objectives.

3.2 Study area

The study was carried out at Soroti City's Arapai Division. East of Uganda is where Arapai Division is located. In the Soroti City Teso sub-region, it is a village. It is Located at an elevation of 1133.09 meters (3717.49 feet) above sea level, Arapai has a Tropical wet and dry or savanna climate .The district's annual temperature is 26.96ºC (80.53ºF) and it is 3.49% higher than Uganda's averages. Arapai usually receives about 285.43 millimeters (11.24 inches) of rainfall and has 282.89 wet days (77.5% of the time) annually. The population of Arapai is 49,500. Arapai is located within 1° 44' 43" North, 33° 37' 30" East. The land area is approximately kilometers. The people of area rely on agriculture for their livelihood.

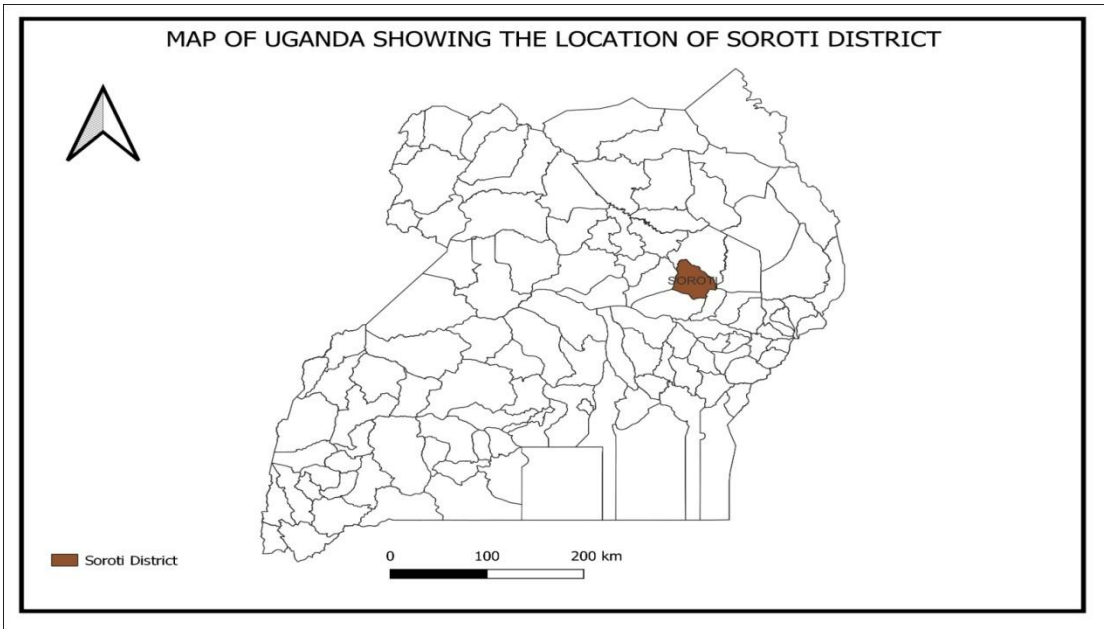
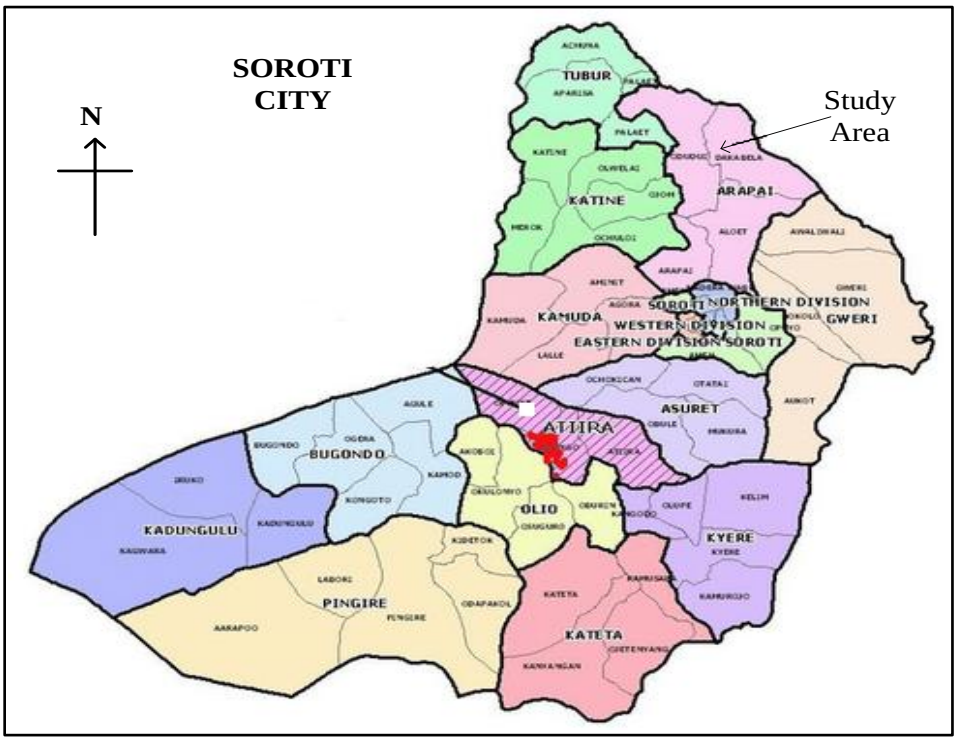


Figure: 1 Map of Uganda showing the location of Soroti City



Source: Field survey, 2023.

Figure: 2 Map of Arapai Division, Soroti City.

3.3 Research design

This study used a mixed design method that is to say quantitative and qualitative research. Various methodological approaches were used in this study, including focus-group discussion as well as structured and semi-structured interviews with households and key informants. Quantitative and qualitative research was used to choose representative samples from the study population and to describe the effects of changing climate and adaptation strategies and also socio-cultural and economic aspects of climate variability in the area.

3.4 Data sources

The study employed both quantitative and qualitative in order to achieve the objectives of the study, was collected from primary and secondary sources. Primary data was collected from individual households and local leaders and questionnaire, interview, and focus group discussions were used, natural resources officer, environmental officer, agricultural officer, and agricultural extension workers of the localities were involved. Alternatively, secondary data provided supplementary information and other existing literature and was gathered from diverse significant sources such as NGO's reports, local government and scientific journals, books and articles were reviewed. The primary rationale behind a mixed methodology used is that it combined the strengths of qualitative and quantitative methods. Generally the reason and central basis of mixed methods is that combining methods provides a better understanding of this changing and complex phenomenon instead of using either approaches alone (Azorin and Cameron 2010).

3.5 Study population, sampling procedures and sample size

Data was gathered from Arapai Division which consists of four Zones. Simple random (SRS) and purposive sampling technique were used, the respondents were chosen from four zones while taking into account the probability amount and its size (Indris & Adem, 2013; Shiferaw *et al*., 2005).

3.6 Sample size determination

Slovene's formula for sample size determination, which asserts that sample size is provided by for any given population size, were used to determine the sample size for this study;

Where, N = is the known population size

n= is the sample size wanted

e= is the level of significance that is 0.05

$$n = \frac{N}{(1 + N e^2)}$$

$$\frac{41,600}{1+41,600 \times 0.0025}$$

$$\frac{41,600}{105} = 396$$

n = 396, Sample size

Respondent's Sample size

RSP= Respondents

N= Population size

n= Sample size

Formula; $\frac{\textbf{RSP}}{\textbf{N}} \times \textbf{n}$

Table 1: shows the Population size and sample size distribution

Category	**Population size**	**Sample size**
Local Council one (LC's)	3993	38
District Environment officer and Natural Resource officer and district officials	735	07
Agricultural college staff and extension workers	6933	66
NGO'S	1680	16
Households	28,259	269
Total	**41,600**	**396**

Source, Field survey, 2023

3.7 Sampling procedure

The study used simple random sampling technique to select household respondents and also purposive sampling was used to select District environment officer, Natural resource

officer, the staff of Arapai Agricultural College, the Non-government Organization and local leaders from among the population of the study area. These techniques were used and it presented manifold opportunities of diverse categories of respondents chosen for the study.

3.8 Instruments of Data Collection

Structured questionnaires, interviews, and focus group discussions were used to collect the primary data, which were both qualitative and quantitative (FGD). Questions with both an open-ended and a closed-ended format were used to gather data on the respondents' demographics, socioeconomic characteristics, and how the climate has affected their livelihoods and methods of surviving in rural areas.

3.9.1 Questionnaire

A questionnaire was used to gather a variety of information on the impact of climate vulnerability on local communities' livelihoods and human wellbeing as well as the intervention actions implemented by both locals and other parties. To this purpose, surveys were written in English and translated into Iteso during data collection.

3.9.2 Interview

Interview was conducted with key informants (KIs), during the interview; the research assistants explained the interview's objective to the subject and made an effort to put the respondents at ease. Moreover, information concerning their capability to notice climate liability by conducting extensive interviews with the key informants from each Parish out of the three parishes selected.

3.9.3 Focus Group Discussion

Focus-group discussions were as well used to collect qualitative information for the study area using qualitative, participatory research methods – including historical timelines, seasonal calendars. Four FGD were conducted one from each zone including Aloet, Dakabela, odudui and Arapai Zones of Arapai division. The aim was to capture aspects such as weather patterns, history of climate-related events, communities' perceptions of climate variability/change, indicators of climate change and variability,

and identification of coping and/or adapting to climate-change-related risks and consequences of climate change on agricultural production, crop productivity and food insecurity at the zone level in all the zones mentioned above.

3.10 Validity and Reliability of the Instrument

The questionnaires were analyzed and verified for the respondents. During pre-testing the questionnaires were administered randomly to the local people, a sample of about 20 district officials and households were randomly selected and interviewed in the two parishes. The pre-testing of this questionnaire aided in bettering the language translation for the respondents' comprehension.

3.11 Methods of Data Analysis

The data collected were analyzed using the Statistical Package for Social Sciences (SPSS, version 23, 2015) software. Both descriptive and inferential analyses including descriptive analysis, correlations and regression model were applied. The qualitative data from focus group discussion was analyzed using content analysis and triangulated during the group discussions to determine the impact of climate variability on socioeconomic livelihood in the area.

3.12 Limitations of the study

This study had significant drawbacks. Given their busy schedules and field travels, the researcher faced difficulty in locating respondents, particularly those who were purposefully chosen to participate in the study, such as LCs and district officials.

Financial resources for transportation, the purchase of the necessary equipment for a study, printing, hiring research assistants for data collection, purchasing SPSS software, or simply rewarding participants, especially LCs who helped mobilize households that participated in the study.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS

4.0 Introduction

This chapter presents the descriptive analysis results, correlations and regressions results and focus group data of the respondents in the study area across the three Divisions, showing climate variability and socioeconomic livelihood. The chapter further elaborates on the findings of climate change and variability-related data. In addition, the chapter relays the descriptive statistics of household livelihood in response to the impact of climate variability.

4.1 Questionnaire Response Rate

A total of 396 questionnaires were distributed to all the target groups of the study in the Arapai Division Soroti City to determine the impacts of climate variability on socioeconomic livelihoods. All the questionnaires distributed were retrieved

Table 2 Response Rate of Questionnaires

Local Council one (LC's)	38	38	*The Majority of the respondents were from households*
DEO and NRO and District officials	07	07	
Extension workers and Agricultural college staff	66	66	
Ngo's	16	16	
Households	269	269	
Total	**396**	**396**	

Source: Field survey, 2023

Table 3 shows the distribution of respondents according to gender. The study found that the majority of respondents (71.5%) were female in the four Zones of Arapai, namely Aloet, Dakabela, Odudui, and Arapai. Male respondents, on the other hand, made up only

28.5 percent of those surveyed in the research area. The female gender is the predominant gender among respondents in this study, accounting for 71.5 percent.

From Table 3 above it depicts the distribution of respondents by age. The results revealed that the majority of participants (27.8 percent) are between the ages of 25 and 31. The dominant age range of the respondents for the present study is 25 to 31 years of age (27.8%).

Furthermore table 3 above displays the educational status of the respondents in the study area. The findings revealed that the majority of the 189 respondents, or 47.7 percent, had not attained education, while 122 completed primary education, or 30.8 percent; 56 completed secondary education, or 14.1 percent; and 29 completed tertiary level education, or 7.3 percent. Also 321 of the 396 respondents were married, with a parallel of 81.1 percent; single, with a ratio of 2.8 percent; and divorced, with a ratio of 16.2 percent.

Similarly table 3 above shows the distribution of respondents according to household size. The results revealed that a higher percentage of respondents had a household size of four to six people, with a percentage of 65.4 percent. This was followed by the group with 1 to 5 households, with a result of 28.5 percent. This indicates that the average household size in the studied area was medium. Nonetheless, a larger number of households were likely to be able to provide manual labor on the farm.

4.2 Demographic Information

Table 3: Demographic information

Respondent's gender		
Gender	**Frequency**	**Percent**
Female	283	71.5
Male	113	28.5
Total	**396**	**100.0**
Respondent's Age		
	Frequency	**Percent**
18-24	14	3.5
25-31	110	27.8
32-38	96	24.2
39-45	76	19.2
46-52	46	11.6
53-59	24	6.1
60^	30	7.6
Total	**396**	**100.0**
Respondent's level of Education		
	Frequency	**Percent**
Primary	122	30.8
Secondary	56	14.1
Tertiary	29	7.3
N/A	189	47.7
Total	**396**	**100.0**
Respondent's Marital status		
	Frequency	**Percent**
Married	321	81.1
Single	11	2.8
Divorced	64	16.2
Total	**396**	**100.0**
Respondent's household size		
	Frequency	**Percent**
1-5	113	28.5
6-10	259	65.4
11-16	24	6.1
Total	**396**	**100.0**

Source: Field survey, 2023

4.3 Correlations of Socio-demographic parameters

It was discovered through Chi-Square value (0.018) that the levels of education significantly influenced the extent at which climate variability affected their livelihoods. Also it was realized through Pearson's Chi-Square value (0.015) that the size of the household is significantly influenced by the extent at which climate variability affected livelihoods. Also, Pearson's Chi-Square value (0.128) shows that the size of the household did not influence the extent at which climate variability affected crop production while Pearson's Chi-Square value (0.248) depicts that the level of education did not affect the extent at which climate variability affected crop production

Table 4 Chi-Square values for some socio-demographic parameters that encourage response to climate variability.

Livelihood Activities	**Size of households** (Chi-Square p-value)	**Remarks**	**level of education** (Chi-Square p-value)	**Remarks**
To what extent has climate variability affected livelihoods	0.015	Significant	0.018	Significant
To what extent has climate variability affected your crop	0.128	Not Significant	0.248	Not Significant

Source: Field survey, (2023)

4.3.1 Pearson's correlation on climate variability, education and gender

According the results from the Table 5 indicate that there is a positive significant correlation between climate variability and education, with an r-value of 0.021.Therefore there is a likelihood that an increase in climate variability could have an impact on education and vice versa. Similarly the Pearson's correlation coefficient (r-value) of -

0.095 between climate variability and gender suggests a very weak negative correlation and the Sig. value of 0.058 is greater than 0.05 indicating that the relationship is insignificant.

Table 5 Pearson's correlation on climate variability and education

Climate Variability	**Education**		**Gender**	
	r-value	Sig.	r-value	Sig.
	0.021	0.016	-0.095	0.058

Source: Field survey, (2023)

4.4 Climate variability and livelihood

4.4.1 Pearson's Correlation for the ratings on climate variability and livelihood

According to table 6, the results indicate that there is a positive correlation between the two variables, climate variability and human livelihood with an r-value of 0.241.The significance level (Sig) of 0.041 suggests that this relationship is statistically significant at the conventional 0.05 significance.

Table 6 Pearson's Correlation for the ratings on climate variability and livelihood

Variables	**r-value**	**Sig.**
Climate variability	0.241	0.041
Livelihood		

Source: Field survey, (2023)

With regards to climate variability impact on income and food security as the result of the delayed onset of rainfall and its unpredictability, all the participants during the Focus group discussion in Aloet Zone unanimously agreed with the views of a 65-year old female participant that:

".....I have seen a shift in the rainy seasons over the past. At first, we had specific times and indicators of rainfall timing. When I was young, we could predict the rains, but now

that it's unpredictable, we used to receive rain for the first season between March and May and the second season from August to November. To predict the suitability or otherwise of a season, experience and old age does not count anymore. One cannot predict when it will rain. However, these days, the rains sometimes come early and stop before our crops mature for harvest. Other times, the rains come late but with very high intensity, which causes flooding. Indeed, the climate has changed" (FDG, 2023).

4.5 Climate Variability and Human health

Results in the table 7 indicate that approximately 13% of the variability in human health can be accounted for by climate variability. According to the F & Sig values, the regression model is statistically significant since the Sig (0.014) is less than 0.05, indicating that the independent variable (climate variability) has a significant impact on the dependent variable (human health).

According to the coefficients section of the Table 7, climate variability has a significant positive impact on human health since the beta value (0.024) is positive and its corresponding Sig. value (0.014), indicating that an increase in climate variability tends to be associated with a slight increase in human health related issues. The constant value indicates that when climate variability is at zero, human health will increases due to due to other factors other than climate variability.

Table **7** Regression Analysis Results for Climate Variability and Human Health

Variables Regressed	**Adjusted R^2**	**F**	**Sig**
Climate variability and Human health	.013	6.144	0.014
Coefficients	**Beta**	**T**	**Sig**
Constant(4.42)	0.024	2.479	0.014

Source: Field survey, (2023)

4.5.1 Climate Variability and coping strategies

In Table 8 respondents identified various coping strategies for climate variability including crop diversity (36.4%), local seed variety (23.3%), agroforestry (22.2%), traditional irrigation techniques (10.6%), and rain water harvesting (7.6%). The study indicates that crop diversity emerges as the most widely recognized approach at 36.4%.

Table 8 coping strategies against climate variability climate

Coping strategies	Frequency	Percent	Remark
Agroforestry	88	22.2	*36.4% of respondents reported crop diversity as one of the coping strategies*
Local seed varieties	92	23.2	
Crop diversity	144	36.4	
Rain water harvesting	30	7.6	
Traditional Irrigation	42	10.6	
Total	**396**	**100.0**	

Source: Field survey, (2023)

With regard to climate variability and adaptation strategies, an elder of 60-years old male farmer at Dakabela said that:

"*…In our community here "in the past we used to have well-defined seasons for planting and harvesting us also had storage facilities like granaries. Now things have changed. We now plant drought resistant crop varieties like cassava and planting number of crops to be able to attain harvest without total crop failure and this has affected our feeding*.

A 71year old female from Odudui said that: *"...Our forefathers had water management systems that worked for centuries and this could give us water when its time of drought and we could even use to water our crops but now some have dried up (FGD, 2023).*

4.5.2 Climate change and variability awareness in the study area

Table 9 shows that that the majority of respondents (67.2%) were aware of climate change and variability, while only 32.8% did not know. This suggests that rural people have a better perception of climate change and variability.

Table 9 climate change and variability awareness in the area

Response	**Percentage %**	**Remark**
Yes	67.2	*The majority of the respondents were aware of climatic changes, that is, (67.2%).*
No	32.8	
Total	**100.0**	

Source (researcher, 2023)

One of the elders said that:

"...It is difficult to forecast when it will rain. Initially, we had precise times and rainfall timing indicators. Early May is usually when the first rains arrive, and by the end of the month, our farms are planted with crops. These days, though, the rains can arrive early and end before our crops are ready to be harvested. On other occasions, heavy rains that arrive later than expected result in floods and it if followed by drought. The climate has altered, and we have seen devastating occurrences of floods and drought destroying our crops and property, in fact (FDG, 2023).

CHAPTER FIVE

DISCUSSION OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This study was intended to contribute to the body of knowledge about the impact of climate variability on the socioeconomic livelihoods in Arapai Division, Soroti City, Uganda. The objectives of the study, as outlined in Chapter 1, were:

i. To determine the implication of climate variability on livelihoods in Arapai, Division, Soroti City.
ii. To identify the impact of climate variability on human health in Arapai Division, Soroti City.
iii. To establish the coping strategies against the impacts of climate variability in Arapai Division, Soroti City.

5.1 Climate variability and socio-demographic factors

According to Table 4, the Chi-square value of 0.018 indicates that the levels of education significantly influenced the extent at which climate variability affected their livelihoods Also it was realized through Pearson's Chi-Square value (0.015) that the size of the household is significantly influenced by the extent at which climate variability affected livelihoods. Furthermore, Pearson's Chi-Square value (0.128) shows that the size of the household did not influence the extent at which climate variabilty affected crop production while Pearson's Chi-Square value (0.248) depicts that the level of education did not affect the extent at which climate variability affected crop production. Ukamaka, D.M., *et al*. (2017), recorded education of household heads increased skills and knowledge that shape agricultural engagements.

In Table 5 the r-value of 0.021and a significance value (Sig. Value) of 0.016 suggests a positive relationship between climate variability and education among the study participants. This positive implies that as levels of education increase, there is a slight tendency for individuals to report experiencing or perceiving climate variability to a slightly higher degree. The study's Sig. Value of 0.016 suggests that education may

significantly influence individuals' perception or adaptation to climate variability. Other studies conducted by Bruine de Bruin and Dugan. A, (2022) who recorded that higher education facilitates understanding climate related risks and found a positive relationship between education and climate variability, also Deressa *et al*. (2010) and Maddison (2006), recorded similar evidence, whereby education of household heads increased the probability of awareness and adaptation to climate variability.

Table 5 showed that the r-value of -0.095 and Sig. values (0.058) suggests insignificant relationship at 0.05 between climate variability and gender. Dymén.C. *et al*. reported gender awareness and the relationship between gender and climate change in Sweden.

5.2 Climate variability and livelihood

According to table 6, the results indicate that there is a positive insignificant correlation between the two variables, climate variability and livelihood with an r-value of 0.241. However, the Sig.value is 0.041implying that climatic variations impacts livelihoods including agriculture, food security and water availability. This is supported by Ndesanjo.B.R& Frensholt, (2023) whose study revealed significant livelihood implications due to changes in rainfall patterns, pasture availability; household perceptions and Livestock mortality was positively associated with extreme climatic events, while food insecurity was positively linked to pasture scarcity. The findings are also in line with Dinar *et al*. (2012), who reported that livelihoods suffer severe losses as a result of changes in climatic conditions in the region of Africa, Zimbabwe inclusive also Matji (2015), who reported that changes in climatic conditions have a significant impact on crops in South Africa.

5.3 Climate variability and human health

According to the coefficients section of Table 6, climate variability has a significant positive impact on human health since the beta value (0.124) is positive and its corresponding sig. value (0.014), indicating that an increase in climate variability tends to be associated with a slight increase in human health-related issues. However, the adjusted R-squared value of 0.013 suggests that climate variability only contributes to 13% of the impact on human health. This indicates that other factors not included in the study such factors include biological (genotype, micro-organisms, and allergies), lifestyle choices, age, unhygienic environment and economic (poor living conditions) that are responsible for incidence of disease in the areas. This result conforms to that of Tunde, A. M., Adeleke, E. A., and Adeniyi, E. E. (2013). It was reported that there is a very strong positive correlation between climate change and human health and that climate variability impacts human health either directly or indirectly in many ways. Similarly Olorunfemi and Adeyemi's 1994 study revealed that rainy seasons in Ilorin are the most common cause of mortality, with vector-borne diseases like malaria, fever, and dengue fever being most prevalent

5.4 Coping strategies against climate variability

According to table 7 crop diversification is the most prevalent coping strategy among respondents, employing 36.4% of them. Local seed varieties and Agro forestry are also popular (22.2%), with 23.2% using local seeds. Traditional irrigation, used by 10.6%, is moderately adopted to secure water supply for crops. Rainwater harvesting, with 7.6% prevalence, shows potential for further promotion and adoption. These findings collectively underscore the importance of diversifying coping strategies to build resilience against climate variability. Crop diversification, local seed varieties, and agroforestry are prominent approaches, while traditional irrigation and rainwater harvesting show potential for further promotion and adoption. This was corroborated with information from the focus-group discussions in Odudui and Dakabela zones in these zones it was asserted that some major water body reservoirs and springs dried up that used to serve as source of water for traditional irrigation during drought seasons and

source of water for domestic use also due to climate variability, It was reported that the major adaptation strategy used is crop diversification as a coping strategy to help minimize total crop failure. This conforms to report by Huang.J and Jiang.J, (2014), which was conducted in China, it was recorded that farmers respond to extreme weather events by increasing crop diversification. In addition In Uganda, Tesfaye and Tirivayi (2020) showed that crop diversification improves household welfare by means of diet diversity and reduced consumption expenditures. A similar study conducted in Uganda on banana-based production systems by Kozicka *et al*., (2020), found that banana-based systems can be enriched by intercropping other crops, which can increase adaptive capacity in the face of climate change or banana disease outbreaks. They suggest that the ultimate outcome is enhanced farm resilience. Michler and Josephson, (2017) research in Ethiopia reveals that households producing diverse crops are less likely to be poor, reducing the likelihood of non-poor households becoming poor.

5.5 Climate related information on community awareness of climate change and variability

In Table 9 the study showed information in response to knowledge of climate variability which reveals that the majority of the respondents 67.2% possess knowledge about climate variability. This was corroborated by the focus group discussion, which reported that people in the area also experienced developing incidences of climate variability, including floods and drought. According to Maponya *et al*. (2013), around 63.3% of South Africans have received climate information. In Mpumalanga Province, South Africa, just 36.7% of people did not receive any information. 94.8% of respondents had seen changes in the weather, while only 5.3% had not. The analysis suggests that the majorities of individuals are aware of climate variability but have been unable to appreciate the full impact of such change affirming with the previous study of Daniel, O (2015).

5.6 Conclusions

The findings of the study indicate the impacts of climate variability on socioeconomic livelihoods of the Arapai Division in Soroti, Uganda. Thus, the implications of climate variability on human wellbeing and community food security cannot be overemphasized. The study also unveiled that the people of Arapai Division, Soroti City, used various coping strategies to cushion the effect of climate variability and extreme weather events on their lives and livelihoods. They were crop diversification, agroforestry, local seed varieties, and traditional irrigation. The study reveals that people's skills and education levels significantly influence their coping strategies and adoption of them. However, crop diversification was mostly used which by the respondents. Therefore, the study advocates sustainable approaches and policy that will enhance the coping abilities of the people of Arapai to the negative consequences of climate variability.

5.7 Recommendations

The study recommends sustainable approaches expected to advance the knowledge of climate variability, encourage and support sustainable coping skills that will drive the needed adaptation lifestyles and programmes.

5.7 .1 Increasing changing climate awareness.

Awareness about climate variability and its impact on agriculture should be raised in communities through adaptation strategies integrating traditional knowledge and modern science. Institutions of learning, including schools, should work with communities to validate practices and strengthen community practices. Indigenous knowledge should be integrated into curricula to foster a fusion between communities and institutions, incorporating it into policies and strategies to curb climate change impacts.

5.7.2 Launching Climate variability adaptation policies.

The government must initiate climate change adaptation policies, involving all-inclusive stakeholder engagement. These policies should incorporate community knowledge to deliver efficient food and health practices. Education is crucial for addressing climate

change's effects on human health and livelihood. Environmental literacy and climate change capacity development should be developed, and school curricula should cover climate change and its health consequences.

5.7.3 Livelihood diversification

Climate change impacts communities' vulnerability and well-being. Livelihood diversification is an effective approach to reduce dependence on climate-sensitive activities and ensure stable income. It expands income-generating activities beyond agriculture, enabling communities to meet daily needs, access education, and healthcare. This approach enhances adaptive capacity, promotes sustainable resource management, empowers marginalized groups, and contributes to local economic development. Integrating livelihood diversification into climate adaptation strategies can improve the adaptive capacity and overall well-being of vulnerable communities.

5.7.4 Foster a comprehensive climate-resilient agricultural approach.

Adopting a holistic approach that includes diversifying crops, supporting local seed varieties, expanding agro forestry, improving traditional irrigation, promoting rainwater harvesting, offering education and capacity building, providing financial support, investing in research and innovation, fostering community engagement, and monitoring and evaluating interventions is advised in order to improve climate resilience in the region. These measures aim to reduce vulnerability to climate-related risks, improve soil quality, and ensure sustainable water management during dry periods.

5.7.5 Promoting climate-resilient health and agriculture ecosystems

A comprehensive approach integrating climate-resilient agricultural practices and healthcare strategies is crucial for community resilience to climate variability's health effects. This strategy includes promoting climate-resilient agriculture, improving healthcare access, raising climate-health awareness, developing disaster preparedness plans, providing mental health support, ensuring safe water and sanitation, conducting health impact assessments, investing in climate-resilient infrastructure, and fostering interagency collaboration**.**

5.7.6 Inculcation of indigenous food preservation approaches

Indigenous knowledge and approaches could be used to promote food security and adaptation procedures among the farmers. For example, through the study, food preservation practices such as hanging of stocks of maize, sorghum and soya beans by the fireplace in kitchens. It will keep crops warm and safe from weevils and makes their seeds last for years. Also the use of granaries to store grains after harvesting to cater for dry seasons. Kitchen gardening will also provide vegetables during dry season. This should not be eschewed; rather it should be inculcated and made to function as a complement to the new scientific method.

5.7.7 Climate-smart agriculture

Climate smart agriculture is recommended for community use to address decreased crop yields and climate change challenges. Techniques include intercropping, agro-forestry, crop rotations, short-season farming, water management, organic carbon management, low carbon emission agriculture, and environmental practices. These strategies aim to increase agricultural productivity, income, and resilience.

5.7.8 Financial support

The government should assist the community through cooperate financing. This is a support that will cater and provide resources needed in order for rural households to farming sustainably and improve their livelihood. It could be through soft loans. Formation of farmers and community groups association and cooperative must be encouraged where soft loans could be garnered by the society. This also includes enhancing of farmers networking for indispensable information through farmer-to-farmer organizations.

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APPENDICES

APPENDIX I: QUESTINNAIRE GUIDE FOR RESPONDENTS

Dear respondents,

I am a student of Kampala international University and pursuing Masters of Science in Environmental Management. You have been selected to participate in the study entitled 'the impacts of climate change on socioeconomic livelihoods in Arapai Sub-county, soroti city, Uganda'' in which the researcher will determine the impacts of climate change on socioeconomic Livelihood in Arapai Sub-county, Soroti City. This study is being undertaken as a partial fulfillment of the award of Master of Science in Environmental Management. The results of this study will add to the already existing body of knowledge and help in the development of future studies. More so, the confidentiality of any data gathered for this study is strongly assured and is sought for academic purposes only. Therefore your kind cooperation in administering this instrument is highly appreciated. Thank you.

<u>Section A</u>: Background information

1. **What is your gender?**

   Female ☐

   Male ☐

2. **What is your age?**

   18-24 ☐

   25-31 ☐

   32-38 ☐

   39-45 ☐

46-52 ☐

53-59 ☐

60 and above ☐

3. What is the highest level of school that you have completed?

Primary ☐

Secondary ☐

Tertiary ☐

Any other specify ☐

4. What is your marital status?

a) Married ☐

b) Divorced ☐

c) Single ☐

d) Widowed ☐

5. **What is the size of your household**?

a) 1-5 people ☐

b) 6-10people ☐

c) 11-16 people ☐

Section B: climate change and Livelihood

6. **Is farming your major source of income?**

   a) Yes ☐

   b) No ☐

7. **Has climate change affected your agricultural income**?

   a) Yes ☐

   b) No ☐

8. **Are there any households affected by Climate induced disasters in the past?**

   a) Yes ☐

   b) No ☐

9. **Has climate change affected your personal savings**?

   a) Yes ☐

   b) No ☐

10. **Has climate change affected your credit accessibility?**

    a) Yes ☐

    b) No ☐

11. **Has climate change affected your loan repayment**

    a) Yes ☐

    b) No ☐

12. **Have you ever experienced the following lately?**

    a) Drought ☐

    b) Floods ☐

    c) Abnormal wind ☐

d) All the above ☐

13. **Are there days when you or your household members were unable to work or were unemployed as a result of climate-related disasters?**

a) Agree ☐ b) strongly Agree ☐

c) Disagree ☐ d) strongly disagree ☐

14. Are Households in your area experiencing food insecurity as a result of climate change disasters such as drought and floods?

a) Agree ☐ b) Disagree ☐

c) Strongly Agree ☐ d) Strongly disagree ☐

15. Which groups and individuals are most affected by climate change?

Indigenous people ☐

Women ☐

Children ☐

Persons with disabilities ☐

16. To what extent has climate change affected livelihoods?

High ☐

Low ☐

Climate Variability and local Farmers Livelihoods

17. Are you aware of climate change?

a) Yes ☐

b) No ☐

18. Has climate change affected your crops?

a) Agree ☐ b) strongly Agree ☐

c) Disagree ☐ d) strongly Disagree ☐

19. To what extent has climate change affected your crops?

a) Badly ☐

b) Slightly affected ☐

c) Not affected ☐

20. Have you noticed new Disease or parasites in the livestock over the past years?

a) Yes ☐

b) No ☐

21. Has climate change led to the emergence of new crop pests and diseases in your area?

a) Agree ☐ b) Strongly Agree ☐

c) Disagree ☐ d) strongly Disagree ☐

22. Has climate change caused the appearance of invasive species in past years in your area? ☐ ☐

a) Agree b) Strongly Agree

c) Disagree ☐ d) strongly Disagree ☐

23. Climate change has led to reduced agricultural productivity?

a) Agree ☐ b) strongly Agree ☐

c) Disagree ☐ d) strongly disagree ☐

24. **What impacts has climate change had on food security?**

a) Increased food prices ☐

b) Food scarcity ☐

c) All the above ☐

25. Has climate change contributed to poverty?

a) Agree ☐ b) Strongly Agree ☐

c) Disagree ☐ d) strongly Disagree ☐

26. Had you or your family member(s) been affected due to damage in physical infrastructures (road, houses, water resources, etc.) due to climate induced disaster(s) over the past years? ☐

a) Agree ☐ b) Strongly Agree

c) Disagree ☐ d) strongly Disagree ☐

27. Have you or members of your household have food shortage due to impact of the climate induced disaster(s)?

a) Yes ☐

b) No ☐

<u>Climate Variability and human health</u>

28. **Which of the following Diseases are most prevalent in humans as a result of climatic changes as compared to past years?**

a) Cough /Cold ☐
b) Respiratory diseases ☐
c) Malaria ☐
d) Diarrhea ☐
e) All the above ☐

29. Has food insecurity led to increased cases of Malnutrition in your area?

a) Agree ☐ b) Strongly Agree ☐
c) Disagree ☐ d) Strongly Disagree ☐

30. Has the incidence of water borne or food borne Disease increased in your family in the past years?

a) Yes ☐
b) No ☐

31. Has the incidence of vector borne Disease increased in your family over last year's than before?

a) Yes ☐
b) No ☐

32. Natural disasters or events due to climate change (first identify the main disaster events in your locality)

a) Flood ☐ b) Thunderstorm ☐
c) Abnormal winds ☐ d) Drought ☐
e) All the above ☐

33. What are the existing traditional or indigenous practices that your community relies on to cope with climate variability effects?

a) Agro forestry b) Local seed varieties

c) Crop diversification d) Traditional rain water harvesting

e) Irrigation

Compiled by: Ruth Apio Kampala international University.

APPENDIX II: RESEARCH BUDGET

NO	ITEM	EXPENDITURE
1	TRANSPORTATION	150,000
2	ACCOMODATION	50,000
3	FIELD RESEARCH ASSISTANTS	200,000
4	COMMUNICATIONS	20,000
5	RESEARCH EQUIPMENT AND STATIONARY	30,000
6	SECRITARIAL WORK	20,000
7	MISCELLANEOUS	20,000
	TOTAL	**490,000**