CLIMATE VARIABILITY ADAPTATION STRATEGIES AND LIVELIHOOD OF SMALLHOLDER VEGETABLE FARMERS IN KAMPALA DISTRICT UGANDA

BY

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A Thesis Submitted to the School of Arts and Social Sciences, Department of Sociology, Psychology and Anthropology in Partial Fulfillment of the Requirements for the Award of the Degree of Doctor of Philosophy in Development Studies

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DECLARATION

Declaration by the Candidate

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To my beloved sons Nicodemus Edwards Kipkoech and Dominic Kipchirchir Kirwa

And to my family in Uganda

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ABSTRACT

Adaptation is no longer optional for farmers given the hostile effects climate variability poses on livelihood. However, adaptation strategies employed vary across locations and categories of farmers. This study investigated the effect of adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district, Uganda. Specifically, the study sought to establish the effect of technological development adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district, determine the effect of government agricultural support programs on livelihood of smallholder vegetable farmers in Kampala district, assess the effect of farm level adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district, and to establish the effect of farm financial management adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district. The study was anchored on pragmatism research paradigm and was grounded in three main theories: diffusion of innovations theory; action theory of adaptation and sustainable livelihood theory. The study adopted an explanatory sequential research design. A mixed research approach was used. The target population included 1083 smallholder vegetable farmers in Kampala district, from which a sample of 292 respondents was selected using stratified simple random sampling technique. The study also targeted 10 key informants that included the 5 officials of the Directorate of gender, community services and production and 5 NAADS officials who were selected purposively. Both quantitative and qualitative data were gathered for this study. Quantitative data was collected using semi-structured questionnaires and later analyzed using descriptive and inferential statistics. While qualitative data was gathered using interview schedules and observation guides and later subjected to content analysis. Validity was determined by consulting experts. Reliability was determined through pilot study in Entebbe municipality, Wakiso District and a reliability value of 0.800 was obtained using Cronbach's alpha coefficient. Basing on multiple regression model r^2 was 0.775 showing that 77.5% of the variation in livelihood of smallholder farmers can be explained by climate variability adaptation strategies. Technological development adaptation strategies (β_1=0.357, p=0.000) had a significant effect on livelihood of smallholder vegetable farmers; government agricultural support programs (β_2= -0.037, p>0.05) did not have a significant effect on livelihood of smallholder vegetable farmers; farm level production adaptation strategies (β_3=0.557 and p=0.000) had a significant effect on livelihood of smallholder vegetable farmers and farm financial management adaptation strategies (β_2= 0.082 and p>0.05) did not have a significant effect on livelihood of smallholder vegetable farmers. Qualitative findings revealed that smallholder farmers sold-off household assets such as crop harvests, livestock like pigs, chicken and goats in order to generate income to purchase farm adaptation requirements, that Covid-19 rendered financial management skills and training important to farmers more than ever before. The study concludes that some adaptation strategies enhanced livelihood while others did not, smallholder farmers diversified adaptation strategies and that adaptation strategies were interrelated. The study recommends that KCCA promotes adaptation strategies as a package for smallholder farmers; strengthening of government agricultural support and financial management adaptation strategies and consolidation of public-private partnerships in addressing hindrances to adaptation by smallholder farmers in Kampala district. Further research should be carried out on climate variability adaptation strategies and livelihood of smallholder urban livestock farmers.

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ABBREVIATIONS & ACRONYMS

AGRA : Alliance for a Green Revolution in Africa

AR4 : Fourth Assessment Report

ASARECA : Association for Strengthening Agricultural Research in Eastern and Central Africa

CD **:** Crop Diversification

CGIAR **:** Consultative Group for International Agricultural Research

COP **:** Conference of Parties

CSTs : Climate Smart Technologies

DANIDA **:** Danish International Development Agency

DFID : Department for International Development

F.A.O : Food and Agricultural Organization

GDP : Gross Domestic Product

RUAF : Resource center on Urban Agriculture and Food security

HLS : Household Livelihood Survey

IFAD : International Fund for Agriculture Development

IIED : International Institute for Environment and Development

IPC : Integrated Food Security Phase Classification

IPCC : Intergovernmental Panel on Climate Change

JICA : Japan International Cooperation Agency

KCC : Kampala City Council

KCCA : Kampala Capital City Authority

LDCs : Less Developed Countries

MAFAP : Monitoring African Food and Agricultural Policies

MoLHUD : Ministry of Lands Housing and Urban Development

NAADS : National Agriculture Advisory Services

NAIVS : National Agricultural Input Scheme

NAP : National Agriculture Policy

NAPA : National Adaptation Program of Action

OLS : Ordinary Least Squares

PEWOSA : Project to Empower Women through Savings and Loan Associations

PRSP : Poverty Reduction Strategy Program

SCCF : Special Climate Change Fund

SL : Sustainable Livelihood

SPSS : Statistical Package for Social Scientists

SSA : Sub-Saharan Africa

TAR **:** Third Assessment Report

UBOS : Uganda Bureau of Statistics

UK : United Kingdom

UNHS : Uganda National Household Survey,

UNCCP : Uganda National Climate Change Policy

UNDP : United Nations Development Programme

UNMA : Uganda National Meteorological Authority

UNFCCC : United Nations Framework Convention on Climate Change

UNCST : Uganda National Council for Science and Technology

UPA : Urban and Peri-urban Agriculture (UPA)

USAID : United States Agency for International Development

WFP : World Food Programme

WHO : World Health Organization

ZFSP : Zambia Fertilizer Support Programme

OPERATIONAL DEFINITION OF KEY TERMS AND CONCEPTS

Adaptation: Adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. The term is herein used to refer to adjustments in some attribute of the agricultural system in response to climate variability and its effects.

Adaptive Capacity: The study defines adaptive capacity as the ability of smallholder vegetable farmers to identify and implement effective actions in response to seasonal fluctuations in climate.

Climate Variability Adaptation Strategies: The term is herein used to refer to mechanisms, activities, decisions, practices adopted by farmers to cope with observed or anticipated climate variability and its effects thus reduce vulnerability. In the study, adaptation strategies include planned or unplanned technological development adaptation strategies, government agricultural support programs, farm level production adaptation strategies and farm financial management adaptation strategies.

Climate Variability: In this study climate variability refers to the seasonal fluctuations in temperature, precipitation and wind.

Farm Production Adaptation Strategies: Refer to changes in farm operational practices as a result of farm-level decisions with respect to farm production in response to climate variability. In this study, farm level changes include; mulching, crop rotation, crop boosters, mixed cropping, changing planting & harvesting, planting drought resistant varieties, planting trees, selling household assets, planting multiple vegetable varieties and burying crop residues to replenish soil fertility.

Financial Management Adaptation Strategies: Refer to farm level responses using farm income strategies to reduce the risk of climate-related income loss. In this study, farm financial adaptations mean decisions with respect to budgeting, paying loan on time, borrowing money from financial institutions, insuring vegetable farm, saving and engaging in other economic activities.

Government Adaptation Strategies: These are institutional responses to address risks associated with climate change and variability. In this study, government agricultural support programs include; agricultural training, agricultural extension services, subsidized credit, agricultural inputs and market support.

Livelihood: Livelihood refers to capabilities, assets (including both material and social resources) and activities required for a means of living. The term livelihood is herein used to refer to household income, household food security, household assets, knowledge acquisition and application and livelihood structures and policies necessary for smallholder farmers' survival.

Smallholder Farmer: A small holder farmer is one who operates between 1-3 acreage, seldom uses production inputs, and prays for rains to come and water their crops and operate on a subsistence basis. In this study a smallholder farmer is one who grows vegetables on relatively small plots ranging between one and two hectares, for sustenance and survival purposes with irregular amount of surplus sold in an informal or local market, having limited or no connection to value chains and is a net buyer of food and uses family labour.

Technological Development Adaptation Strategies: Refer to techniques, equipment, knowledge and skills employed by farmers to cope with adverse impact of floods, droughts and wind surges. In the study, technological adaptations include; using weather forecast and climate information, water harvesting, using crop boosters, changing soil conservation technologies and using new crop varieties.

Vegetables: The term is herein used to refer to edible parts of a plant (excluding flowers, seeds and stems) such as fruits, leaves and roots of a plant.

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter presents the background of the study, statement of the problem, main objective of the study, specific objectives and research hypotheses. It also presents the justification of the study, significance of the study, scope of the study, limitations of the study and chapter summary.

1.2 Background of the Study

Globally, an estimated 570 million farms are considered small and 85% of global farms are less than 2 hectares in size (Lowder *et al.*, 2016). Smallholder farmers operate on less than two hectares, majority are poor, experience food inadequacy and have limited access to markets and services, cultivate land and produce food for a significant part of the world's population (FAO, IFAD & WFP, 2015). In defining a smallholder, this study adopted the operational definition used by the Ministry of Agriculture, Animal Industry and Fisheries (Republic of Uganda, 2011) which defines smallholder farmers as those farmers who operate small pieces of land, seldom use production inputs, irrigate their crops, work for survival, have no access to credit, have poor infrastructure, are exposed to high temperatures as well as depend on rain-fed agriculture. Thus, smallholder farmers in this study refer to farmers who have the above characteristics and particularly plant vegetables for sustenance and survival purposes.

Smallholder farmers in Latin America and the Caribbean represent a population of approximately 66 million people responsible for producing some of the region's most important commodities, such as corn, peas and potatoes, support maintenance of rural and urban households as well as local and regional economies. Therefore, smallholder

farming contributes towards economic growth and farmer's livelihood. In the current study indicators of smallholder farmers livelihood include; household income, household food security, household assets, knowledge acquisition & application and livelihood structures and policies.

In the eastern coast of the Southern Africa particularly in Mozambique agriculture is mostly practiced by smallholder farmers, who account for 99 per cent of the total number of farming households and farm 96 per cent of the 5.6 million ha of cultivated land. Most of the farmers practice rain-fed subsistence production on small areas which is constrained by limited integration into markets, low use of external inputs, low coverage of extension services, lack of storage facilities, high post-harvest losses, poor transport facilities, high transaction costs and difficult access to financial services (Silici *et al.,2015*).

In sub-Saharan Africa smallholder farmers and families produce 80% of their food stock (Food and Agriculture Organization of the United Nations, 2017). Kenya's agriculture sector is dominated by smallholder agricultural production of 0.2 to 3 hectares, accounting for 78 percent of total agricultural production. Smallholder farmers in Kenya dominate mixed agriculture in the country and grow food crops like corn, beans, cowpeas, pigeon peas, sorghum, millet and green gram, fruit trees (citrus, mango) and rear animals such as chickens, goats, donkeys and cattle (Muema *et al*., 2018). Thus, the significance of smallholder farming is evident in other East African countries.

In Uganda, it is estimated that 80% of smallholder farmers operate between 1-3 hectares, seldom use appropriate raw materials in agriculture, need rain to irrigate their crops and work to earn a living while large scale farmers deal mainly in cash crops and

livestock, operate large pieces of land, have access to farm inputs and credit (Republic of Uganda, 2011). Thus, farmers in Uganda are categorized into two categories with distinct features. This study focused on the category of smallholders which envisages farming as a means of survival rather than a business. The study was triggered by a desire to evaluate the livelihood of smallholder vegetable farmers in Kampala district, Uganda.

According to the Uganda Bureau of Statistics (2020), agriculture is one of the key economic activities in Uganda, employing the highest percentage of the work force (64.3%), accounting for the largest share of employment (36%), it contributes about 21.9% of Gross Domestic Product (GDP), accounts for over 40% of total exports and is a source of food and nutrition security for numerous Ugandans. This shows that the sector's contribution to the nationwide development as well as livelihoods of millions of Ugandans, especially smallholder vegetable growers cannot be underestimated.

According to the World Watch Institute, more than 800 million people worldwide grow vegetables, fruits or raise animals in cities, producing an amazing 15-20% of the world's food (FAO, 2016). This means that the importance of vegetables has come to be known all over the world. According to Ngegba *et al*., 2016), China was the largest producer of vegetables, accounted for more than half of world's production, followed by India, the United States, Turkey, Iran and Egypt, and 60% of city vegetables came from urban and suburban areas of Shanghai.

Urban and Peri-urban agriculture (UPA) in Kampala can be traced to the Idi Amin regime (1971-1979). The official economy of the time was severely affected by the regime's "War of economic independence" which was characterized by the eviction of the Indian minorities in 1972 plus the implementation of Structural Adjustment

Programmes (SAPs) which led to drastic decline in employment, government spending, trade liberalization, rising interest rates and currency devaluation. As a result, unemployment rose, real incomes fell, commodity prices rose, social services collapsed and many urban households shifted to informal sector income generating activities such as urban agriculture (Sabiiti *et al*., 2014).

According to Maxwell 1995 as cited in David *et al*. (2010) households in Uganda engaged in agriculture in the 1970s to cope with difficult economic conditions under the Idi Amin dictatorship and after 1986 when the Museveni "Movement" government came to power, people felt safe enough to participate in agricultural production in neighboring areas and in the 1990s the impact of structural adjustment programs coupled with greater security strengthened urban agriculture. Urban agriculture in Kampala gained popularity as a development strategy due to increasing pace of urban population growth, economic and political changes (David *et al*., 2010). Thus many authors indicate that crop cultivation and livestock rearing in Kampala city is not a new phenomenon and have identified factors responsible for the emergence of urban farming in Kampala.

In addition, by early 1990's urban agriculture became prevalent in both the built-up areas of Kampala city and the suburban areas, with 35% of households engaged in agriculture mainly crop farming, accounting for 56% of the land in 1992 while about 70% of poultry products consumed in Kampala were produced in the city (Maxwell 1995 as cited in David *et al*., 2010). Hooton *et al*. (2007) state that vegetable farming has always been part of Kampala's economy and has been an important survival strategy for the urban poor, especially women.

Urban agriculture may take place in localities within the city or in the suburban areas. In particular, urban agricultural activities can take place in one's residence (on-plot) or on land outside an individual's residence (off-plot), on private land (owned, rented) or in public places (parks, nature reserves, road sides, streams and railways) or in semi-public land (schoolyards and hospitals) (Hampwaye *et al.*, 2009). The study focused on smallholder vegetable farming within the city and outlying areas with an emphasis on-plot and off-plot farm locations in the five boroughs of Kampala district.

According to Prain and Lee-smith (2010), many residents of Kampala grow horticultural crops such as fruits, vegetables and flowers; root tubers like cassava, yams, sweet potatoes; legumes and grains; keep animals such as cows, pigs, sheep and goats and others plant paddy rice in wet areas like swamps. Popular vegetables grown within Kampala city include; Amaranthus (*dodo, bugga, and jobyo*), kales, spinach, cabbages, egg plants and bitter berries (*entula*). The study focused on urban crop farming particularly vegetable growing among smallholder farmers in Kampala district.

Urban farmer groups in Kampala are categorized as follows: a small group of urban farmers who produce mainly for the town market (this group is usually quite wealthy and has access to commercial credit); a second group is located mainly in suburban areas of the city; a third group of farmers engaged in urban agriculture to achieve a level of food security (their income comes mainly from non-agricultural sources and most of their food is purchased from the markets, but yet agriculture remains an important activity); and finally, a larger group who cultivate because they have no other means, often single women with children who have recently been widowed or abandoned by their husbands (Opitz *et al.*,2016). According to Lee-smith (2010) and RUAF foundation (2015) the largest group of people involved in urban farming are the urban

poor who practice urban agriculture to meet various household needs. This study looked at farmers in Kampala district who possessed characteristics of a smallholder farmer.

The benefits of urban horticulture include; enhancing household food security and nutrition, lessening household expenditure on food items, source of income and employment, increased access to healthy and fresh foods, enhanced networking and interaction among urban neighbors, supply city markets with fresh foods and complements rural food supply (Olivier, 2017; Yaro *et al*., 2016). Increased practice of urban vegetable farming in Kampala district can be linked to several benefits such as improving household income, household food security, household assets and reducing household poverty. Therefore, the study looked at urban vegetable farming as a survival strategy of smallholder farmers in the five divisions of Kampala district.

Unfortunately, smallholder farmers face the following challenges: climate change which is mainly due to global warming, low levels of production and productivity, pests and diseases; insufficient infrastructure for instance storage facilities, transport, irrigation equipment; lack of better access to input and output markets; insecurity of land ownership, unequal access to land, very small landholdings, unequal land distribution and limited financial access (Republic of Uganda, 2013). Therefore, smallholder farmers face both climate and non-climate change related challenges which may hinder adoption of adaptation practices and thus affecting livelihood. Therefore, this study looked at climate variability adaptation strategies being adopted by smallholder farmers to reduce the negative impact of climate variability on vegetables and the effect of the strategies on farmers' livelihood.

In support, authors believe that smallholder farmers, especially in sub-Saharan Africa are the most affected by climate variability as they face challenges such as limited credit

access, inadequate infrastructure, already extreme temperatures, over reliance on rain-fed agriculture and poverty (Ringler, 2010). According to Garcia and Markandya (2015), the urban poor who live in informal settlements and make up about 60% of the Kampala population, are more susceptible to the impacts of climate change and variability, especially floods because they are typically more exposed and have fewer capacities to recover. This is why the study sought to examine adaptation strategies and livelihood of smallholder vegetable farmers in Kampala amidst climate change and variability challenges. In addition, due to increasing population, rural-urban migration, shrinking urban space, increasing urban poverty and rising unemployment, Kampala Capital City Authority and other stakeholders are encouraging urban residents to embrace urban farming.

The term climate variability is often used interchangeably with climate change but have different meanings. The United Nations describes climate change as climate change over a relatively long period of time, resulting directly or indirectly from human activities and the natural variability of climate (United Nations, 2015). The Intergovernmental Panel on Climate Change (2018) defines climate change as gradual change in all the interconnected weather elements on our earth over a span of approximately 30 years. It adds that, the present day climate change is largely due to human activity such as the burning of fossil fuels, such as natural gas, oil, and coal, which releases so-called greenhouse gases into the Earth's atmosphere. The gases trap the heat of the sun's rays in the atmosphere, causing an increase in the average temperature on earth and thus global warming.

The Intergovernmental Panel on Climate Change (2018) defines climate variability as the way in which climate fluctuates from year to year above or below long-term

averages. On the other hand, the United States Agency for International Development (2007) defines climate variability as variations in the mean climatic state at all temporal and spatial scales beyond individual weather events that includes widespread droughts, floods and other conditions resulting from periodic El Niño and La Niña events of the El Nino Southern Oscillation. According to the study, climate variability includes seasonal fluctuations in temperature, precipitation and wind patterns above or below longer term averages.

According to IPCC (2022), changes in several climate impact drivers have already emerged in all regions of Europe including increases in mean temperature and extreme heat, decreases in cold spells, lake and river ice has decreased in northern Europe, west and central Europe and Mediterranean. Frequencies of warm days and nights, heatwaves have increased since 1950, while the corresponding cold indices have decreased. The IPCC Working Group I of the Sixth Assessment Report (2022) adds that during recent decades mean precipitation has increased over northern Europe, west and central Europe and Eastern Europe and precipitation extremes have increased in northern Europe and Eastern Europe.

In the mountain district of Napal an agrarian economy and dependent on monsoon rain, climate change and its impact on agricultural productivity and production has already been noticed. The average landholding is only 0.68 hectares and about 54 per cent landholdings are less than 0.5 hectares. In addition to traditional and staple crops, there is also a trend of cultivating other non-staple crops such as legumes, seasonal vegetables, potatoes and other cash crops. An analysis of climate data showed that the increase in annual average, maximum and minimum temperature for 1989-2012 period was 0.02, 0.06 and 0.01°C, respectively. The maximum temperature increase was

0.03°C in January and 0.08°C in July. The increase of average minimum temperature was 0.06°C in January and 0.04°C in July while the average rainfall increase per year for the period was 42 mm. Farmers in Napal use improved technologies, such as rain water harvesting to cope with the consequences of climate change (Joshi *et al*., 2017).

The African continent is characterized by rising average temperatures, extreme and lowest temperatures in many locations and the variability of rainfall and decreasing levels of many lakes (Ogallo, 2009). Africa is particularly vulnerable to climate change and variability (Recha *et al*., 2017) and its susceptibility to climate change is attributable to dependence on climate-sensitive economic sectors, widespread poverty, limited funds, inadequate infrastructure, high illiteracy levels and misuse of natural wealth (Smith *et al*., 2011).

At the regional level, future climate scenarios developed for East Africa basing on the results of modeling exercises show a rise in mean yearly temperatures ranging from 0.7 º C to 1.5 º C by 2020 and from 1.3 º C to 4.3 º C by 2080, a rise in average annual precipitation by 2060's with highest proportion increase expected in December, January and February, variations in extreme events for instance flooding, droughts, heat waves, storms (IPCC Fourth Assessment Report, 2014). Kenya, one of the East African nations is known for its unpredictable, erratic rainfall which fluctuates from year to year and occurs throughout the year, its temperatures have been warming, minimum and maximum temperatures have increased while its diurnal range of temperature for Nairobi decreased between 1960 and 2005 (Government of Kenya, 2010).

The average temperature in Uganda is predicted to rise by up to 1.5 degrees Celsius in the next 20 years and by up to 4.3 degrees Celsius by the year 2080, while rainfall is predicted to increase by 10 to 20 percent in most parts of the country (IPCC Fourth

Assessment Report 2007, as cited in UN-Habitat, 2009). Uganda's highest rainfall percentage increase was predicted for December, January and February which are historically the driest months for many parts of the country (Hepworth & Goulden, 2008)

It was anticipated that Kampala, the country's capital and largest city, would have a rise in mean near-surface temperature of about 1.5°C, a slight decrease in precipitation of 20mm and an increase in the intensity of both heavy rains and sudden storms both during and outside of the wet seasons (Garcia & Markandya, 2015). In recent years, flooding has become more frequent in urban areas around the world (Lwasa, 2010; UN-Habitat, 2014). The UN Desinventar database (2018) shows that between 1993 and 2014 there were 11 flooding episodes in Kampala city. Garcia and Markandya (2015) report that severe floods occurred frequently along the Lubigi catchment's main channel, sometimes lasting more than a day and reaching depths of up to 2 meters. Floods in Kampala cause deaths interrupt mobility and transport, lead to disease outbreaks, damage crops while droughts reduce water supply thus affecting livelihoods.

According to Mwerera *et al*. (2010), Uganda was listed as one of the nations at danger of suffering from the effects of climate change. The rising temperatures, increased droughts and floods affect productive capacity of the crops, crop growth, land quality, food quality and increase crop pests and diseases (Sikha *et al*., 2019; Maharjan & Joshi, 2013; MAFAP country report series, 2013; Odewumi *et al*., 2013) and this will further erode livelihoods (Food and Agriculture Organization, 2016).

Weather variations in Uganda affect crops, aquaculture and livestock. According to the Ministry of Agriculture, Animal Industry and Fisheries (2018), there is a significant direct and indirect influence of climate change on agriculture which if poorly handled,

might have disastrous effects on the economy. A decline in agriculture growth from 1.5% in 2004-2005 to 0.4% in 2005-2006 is attributed to climatic variations (Ministry of Water and Environment, 2015). From 2007 to 2010/11 the contribution of agriculture to GDP decreased from 51.1 percent in 1988 to 33.1 percent in 1997 to 22.7 to 24.1 percent (MAFAP, 2013). These effects more than anything else compel farmers to adapt in order to lessen susceptibility, boost resilience and so maintain a livelihood. This means that climate variability is a development issue which must be incorporated in development policy formulation at national, municipal and local governments clearly spelling out mitigation and adaptation efforts.

The universal call for climate action is to all who can commit themselves to addressing the climate emergency. For instance, in September 2015, the member states of the United Nations agreed on 17 Sustainable Development Goals, including SDG number 13 which argues countries to act immediately to tackle climate change and its consequences (United Nations Development Programme, 2019). Furthermore, on 12 December 2015, United Nations member states ratified the Paris agreement and pledged to make ambitious steps to mitigate climate change and improve the capacity to adapt to its consequences (United Nations, 2015).

Moreover, on 23 September 2019, during the climate action summit held in New York the UN Secretary-General António Guterres urged UN member states to ensure that adequate adaptation measures are taken to safeguard people, livelihoods and ecosystems, especially people living in areas most vulnerable to climate variability and change (UNDP, 2019). Therefore, it is argued that combating the effects of climate variability on smallholder farming is the way to sustainable livelihoods.

The UN Framework Convention on Climate Change highlights two main strategies for climate change and variability: mitigation and adaptation, while adaptation aims to lessen the negative effects through a variety of system-specific interventions, mitigation strives to slow down climate change by cutting GHG (Greenhouse Gas) emissions (UNFCCC, 2015). Adaptation has become a top priority for policy formulation and has sparked action both inside and outside of the climate change negotiations. This study focused on technological development, government agricultural support programs, farm level production and farm financial adaptation strategies that were used by smallholder farmers in 2020 to safeguard livelihoods.

In Africa a range of options is considered potentially effective in reducing future climate change risk. African farmers use agricultural and livelihood diversification strategies to cope with climate change, enabling them to spread risks and adjust to shifting climate conditions. These include; adjusting cropping choices, planting times, or size, type and location of planted areas, the use of drought-tolerant crop varieties, crop diversification, agro-ecological and conservation agriculture practices such as intercropping, integration of legumes, mulching and incorporation of crop residues and diversification of income sources to offset reduced yields or crop losses by shifting labour resources to off-farm work, or by migrating seasonally or longer term (IPCC, 2022).

In southern Africa, changes in planting dates provide farmers with greater yield stability in uncertain climate conditions (Nyagumbo *et al*., 2017). In some regions of West Africa small-scale irrigation including; the digging of ditches, holes and depressions to collect rainwater is widely adopted and promoted to support national food security (Makondo & Thomas, 2018). In Ghana, farmers are changing planting schedules and

using early maturing varieties to cope with late-onset and early cessation of the rainy season (Antwi-Agyei *et al*., 2015).

In Ethiopia, Rwanda, Tanzania and Uganda farmers are striving to improve irrigation efficiency to mitigate growing water stress (Connolly-Boutin & Smit, 2016 as cited in IPCC, 2022). In Tanzania, diversified crop portfolios are associated with greater food security and dietary quality while in Kenya levels of crop diversity are higher in villages affected by frequent droughts, which are the main cause of crop failure (IPCC, 2022).

Farmers in Kampala are increasingly using irrigation from rooftop rainwater harvesting, open stream, deep well and main sewerage. Rooftop rainwater harvesting appears to be a promising coping strategy for supplying water in the face of scarcity helps to arrest surface water runoff, thereby reducing soil erosion and flooding (Sabiiti *et al*., 2014). Kampala Capital City Authority has formulated an action plan and identifies adaptation goals such as reducing climate change effects, losses, susceptibility and increasing the resilience of communities (Kampala Capital City Authority, 2016).

Despite progress, adaptation gaps exist between current levels of adaptation and levels needed to respond to impacts and reduce climate risks. Moreover, Uganda's approach to climate variability adaptation has concentrated more on rural smallholder farmers than urban farmers. Most observed adaptation strategies in Kampala district are fragmented, small-scale, designed to respond to current impacts or near-term risks and their effect on smallholder farmers' livelihood is dispersed throughout reports and project documents. In light of this context, the study examined climate variability adaptation strategies and livelihood of smallholder vegetable farmers' in Kampala district, Uganda.

1.3 Statement of the Problem

Deteriorating livelihood of smallholder vegetable farmers attributed to the negative effects of climate variability remains a global concern for developed and least developed countries. When compared to other districts, Kampala district which is also the country's capital and largest city shows one of the highest incidences of declining livelihoods of smallholder vegetable farmers. As a result of climate change and variability, urban smallholder vegetable farmers in Kampala experience increased crop failure, food insecurity and increased vulnerability. According to Uganda Bureau of Statistics (2021), four in every ten households (47%) in urban areas are food poor compared to two (22%) in every 10 households living in the rural areas. The report adds that twenty percent (20%) households in Kampala region were food poor in 2016-2017 and 5% were food poor in 2019-2020.

Despite overwhelming evidence on the vulnerability of smallholder farmers to climate variability, many urban authorities have not comprehended the phenomenon of adaptation strategies. In order to address widespread diminishing crop productivity, rising food insecurity, and rising crop pests and diseases, appropriate adaptation strategies must be planned, supported, implemented and evaluated.

KCCA has demonstrated its commitment to the livelihood of smallholder vegetable farmers as evidenced by the introduction of the Urban Agriculture Ordinances (2006) and the formulation a climate action plan that spells out the district’s climate change adaptation goals. Smallholder vegetable farmers have introduced several adaptation strategies to minimise the impact of climate variability but the measures are not adequate, have not brought any tangible success and as consequence smallholder vegetable farmers are struggling to survive. Understanding the effect of climate

variability adaptation strategies on the livelihood offers smallholder vegetables farmers a chance to address widespread climate variability risks, declining crop productivity and thus escape poverty.

Most studies conducted on adaptation strategies so far have tried to identify adaptation strategies in rural areas rather than urban areas. Few studies have been carried out in urban areas, for instance (Odewumi *et al*., 2013) conducted a study in Ibadan Metropolis; David *et al*. (2010) in Kampala and Masvaure (2015) in Glen and Norah Townships in Harare which tends to mask the urban context. In addition, few studies linked adaptation strategies to farmers' livelihood for instance, Defang *et al*. (2017); Diallo *et al*. (2020), Ogada *et al*. (2020) and Gebru and Mworozi (2015).

Therefore, the study set out to examine the effect of climate variability adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district. It will also make policy recommendations to help farmers overcome their adaptation challenges.

1.4 Broad Objective of the Study

The main objective of the study was to examine the effect of climate variability adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district, Uganda.

1.4.1 Specific Objectives

The study's specific objectives were:

i. To establish the effect of technological development adaptation strategies on livelihood of smallholder vegetable farmers.

ii. To determine the effect of government agricultural support programs on livelihood of smallholder vegetable farmers.

iii. To assess the effect of farm level production adaptation strategies on livelihood of smallholder vegetable farmers.

iv. To establish the effect of farm financial management adaptation strategies on livelihood of smallholder vegetable farmers.

1.5 Research Hypotheses

The study on climate variability and livelihood of smallholder vegetables farmers sought to test the following hypotheses:

H_{01} : Technological development adaptation strategies have no significant effect on farmers' livelihood

H_{02} : Government agricultural support programs have no significant effect on farmers' livelihood.

H_{03} : Farm production adaptation strategies have no significant effect on farmers' livelihood

H_{04} : Farm financial management adaptation strategies have no significant effect on livelihood of farmers.

1.6 Justification of the Study

There is a great international need for enquiries and data on agricultural adaptation strategies that can promote sustainable livelihoods in the face of climate change and variability in Africa and particularly urban areas. The study's aim is to provide insightful information that should be recorded, documented and made available for replication in other urban areas, in the rest of Africa region and in the worldwide information community.

Research pertaining to smallholder adaptation strategies and livelihood is not widely available and is inadequate for urban farmers. The relationship between adaptation strategies and livelihood has not been closely studied in the context of urban settings instead focus has been on rural areas in most studies. Therefore, this study would contribute to a new adaptation typology in urban agriculture, a typology that works for urban smallholder vegetable farmers by improving their livelihood. The new typology could be a ground breaking that changes the livelihood of smallholder farmers.

This study is timely since the concern about how climate change may affect agriculture and in turn, food productivity globally and particularly for farmers in less developed nations like Uganda is growing. In Uganda, agriculture is one of the most important economic sectors as it contributes 31% of export earnings, 23.7% of GDP and 70% of the country's labour force (UBOS, 2020). The sector serves as the foundation for a large portion of the nation's industrial activity since most industries are agro-based (Ministry of Water and Environment, 2015). Urban agriculture plays an important role in the livelihood of the people as it is a source of income, food and has a lot of nutritional value. Thus a study of this nature is timely as it proposes strategies for improving urban agriculture.

The study assessed climate variability adaptation strategies and livelihood of smallholder farmers. The effectiveness of adaptation strategies consequently determines whether or not the world would succeed in reducing poverty, hunger, enhancing good health, reduce inequalities, and maintain sustainable communities. The study supports the achievement of the global Sustainable Development Goals (SDGs), including Goal 1 (No Poverty), goal 2((zero hunger), Goal 3 (Good Health and Well-Being), Goal 7 (Affordable and Clean Energy), Goal 10 (Reduced Inequalities), Goal

11 (Sustainable Cities and Communities) and Goal 12 (responsible consumption and Production) and goal 13 (climate action). According to a study by the high-level panel of distinguished individuals on the post-2015 development agenda, the new development agenda should put a realistic emphasis on issues including poverty, hunger, water and sanitation, education and healthcare. The new development agenda should also address a number of intersecting challenges that are not specifically addressed by a single goal but are covered in many of them. Peace, inequality, climate change, cities, issues affecting young people, women and girls as well as sustainable patterns of consumption and production are among them. But above all, attention should be paid to climate change and variability adaptation, as it would determine whether or not countries can achieve their goals (United Nations, 2013).

This study incorporates adaptation tactics of smallholder vegetable growers. Understanding climate variability coping strategies in urban environments can help reveal the most appropriate climate change adaptation strategies for urban vegetable farmers. This is because one of the fundamental decisions that all urban areas must face concerns the coping strategies to be applied or adopted in the face of climatic variations.

The study is an attempt to help urban planners, social groups, climate change and agricultural institutions to better understand the challenges, stressors and the factors that underlie urban vegetable productivity. It helps prepare for the future by formulating policies, plans and investments that integrate adaptation strategies that take into account the adaptability of smallholder farmers, increasing urban resilience and improving livelihoods.

Similarly, livelihoods vary along the continuum from rural to inner city areas due to variations in the availability and access to resources; distinctions in the context of

vulnerability; and variances in the structures, guidelines and procedures that affect families. Urban families may employ spatially dynamic means of subsistence, with individuals utilizing resources widely dispersed both within and outside of cities, and looking for opportunities to use household resources in various locations (Prain & Lee-Smith, 2010). Therefore, it is important to establish context specific results regarding livelihood of smallholder farmers that provides location and sector specific knowledge about adaptation strategies, vegetable production and climate variability within the district thereby developing a body of knowledge specific for Kampala district and strengthening farmers' resilience to climatic variations.

1.7 Significance of the Study

The study contributes to understanding of smallholder farmers' needs for development of working adaptation strategies. The study motivates policy makers to consider adaptation policies since an awareness of adaptation strategies facilitates municipal authorities to structure policies according to the adaptation needs of smallholder farmers. This can also help to identify best ways of protecting farmers' livelihood from agriculture risks and the effects of ineffective risk management strategies.

In addition, findings of the study provide the directorate with information on how adaptation strategies affect urban farmers' household income, financial independence, food availability and household assets. The study results can help the directorate of gender, community services and production to improve training in urban agriculture adaptation practices. The results can help the directorate initiate collaboration among other KCCA directorates and stakeholders to help plan the advancement of urban agriculture within the district.

The findings of the study provide extension officers with information to re-evaluate smallholder farmers' adaptation options, livelihood assets, capabilities, training and strategies to promote knowledge, innovation as well as best practices amidst climate variability.

The findings of the study provide smallholder farmers with information to rethink their adaptation practices, understand those factors which hinder or enhance ability to adopt appropriate strategies. This means that the findings offer insight into usefulness of adaptation strategies in livelihood transformation. The findings of the survey will be disseminated to farmers through oral presentations in workshops organized across the five divisions of Kampala district.

Findings of the study, in thesis form will be made available at the Moi University Library and published in open access journals. The thesis is a key reference document for scholars seeking authoritative answers about adaptation strategies and livelihood of urban smallholder vegetable farmers.

1.8 Scope of Study

The investigation was carried out in Uganda's Kampala district. With a population of 1,680,600 Kampala district is home to Uganda's largest metropolis (UBOS, 2020). The area was specifically chosen because urban and peri-urban agriculture, which effectively uses home and municipal waste plays vital roles in food and nutritional security, employment and livelihoods of an increasing population (Sabiiti *et al*., 2014). The study's scope would be too broad if the researcher included other urban districts, this would make it impossible to complete the study within the time and budget allotted. However, the study results will be replicable to other cities and towns.

Conceptually, the study focused only on examining smallholder vegetable farmers' livelihoods and techniques for coping with climate unpredictability in the Kampala district. Adaptation strategies in the study included; technological development adaptations, government agricultural support programs, farm production adaptation strategies and farm financial adaptation strategies. The concept livelihood was used in the study to imply increased household income, household assets, reduced vulnerability, food security and more sustainable use of natural resource base.

Four objectives served as the foundation for the study on climate variability adaptation strategies and livelihood of smallholder vegetable farmers in Kampala district. The focus of the study was directed to smallholder farmers. Studies show that smallholder farmers are especially susceptible to the consequences of climate change since they struggle with a variety of issues such limited financial availability, inadequate infrastructure, already high temperatures, reliance on rain-fed farming, and general poverty (Ringler, 2010).

Due to the increased frequency of flooding, windstorms, and temperature fluctuations in the year, the study was only conducted for the year 2020. According to the Uganda National Meteorological Authority's (UNMA) seasonal climate outlook for September 2019 to January 2020, several districts in Uganda would occasionally experience outbreaks of heavy showers and thunderstorms that would cause flash floods in most urban areas and landslides in hilly areas. It was also anticipated that most locations would experience near-normal rainfall from March to May 2020 and a tendency toward above average rainfall. The central region had sporadic showers and thunderstorms throughout June, July, and August. These circumstances were predicted to last until the end of early- to mid-June, when dry conditions were predicted to set in and persist up

to mid- July while there was near normal to below normal rainfall in September to December 2020 (UNMA, 2020).

1.9 Chapter Summary

The chapter has examined the concept of smallholder agriculture, climate variability and livelihood of smallholders; the consequences of climate variability on national growth and smallholder urban farmers; and efforts by international organizations, bodies, urban policymakers, and vegetable farmers to adapt to climate variability in order to ensure sustainable livelihoods. As a result, the chapter also includes a description of the research problem, general objective, specific objectives, hypotheses, significance of the investigation, rationale for the study and scope of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Chapter two highlights a review of literature on the concept of livelihood, climate variability, climate variability adaptation and adaptive capacity. It revolves around previous studies on climate variability adaptation strategies particularly; technological developments, government agricultural support, on-farm production and the farm financial management adaptation strategies. Finally, the chapter presents the conceptual and theoretical frameworks guiding the study.

2.2 Livelihood, Climate Variability, Climate Variability Adaptation and Adaptive Capacity Concepts

2.2.1 Livelihood

The term "livelihood" refers to a means of subsisting or survival and encompasses what people do in order to make a living, including those resources that give people the ability to build a satisfactory living, the risks that people must consider in managing their resources, and the institutional and policy context that aids or hinders people in their pursuit of a viable or improved living (Ellis & Freeman, 2005). A livelihood, according to Chambers and Conway (1992), consists of the skills, possessions (stores, resources, claims, and access) and activities necessary for a way of life. Carney expands on Chambers and Conway's definition of livelihood by defining a livelihood as consisting of the abilities, assets (including both material and social resources) and activities necessary for a means of subsistence (Carney, 1998). The term livelihood describes the resources, risks, assets, activities, policies, institutions, strategies that support or obstruct individuals in search for a sustainable livelihood. Livelihood research was placed at the centre of Development Studies in the late 1990s and early

2000s, when the Sustainable Livelihood Framework that focused heavily on the poor was promoted by the UK state Department for International Development (DFID).

As a result of rapid urbanization the urban poor are faced with the problem of urban poverty, unemployment, underemployment, hunger and malnutrition and most poor urban households spend between 30 and 80% of their household income on food alone (Mougeot, 2006). The urban poor often rely on the informal economy, live in overcrowded settlements and have limited access to basic social needs including water, sanitation health and formal social safety nets (UN-Habitat & World Food Programme, 2021).

The East African region is one of the most food insecure regions in the world, the food security situation in East Africa deteriorated in 2020 because of the covid-19 pandemic. As a result of multitude of climate change related shocks, such as recurrent droughts, floods, desert locust infestation, Covid-19 induced loss of livelihoods leading to decline in income which was accompanied by significant increase in food prices that worsened the situation with food insecurity reaching unprecedented levels (UN- Habitat & World Food Programme, 2021). World Food Programme estimated that regional food insecurity peaked at 50.3 million people in 2020 and among this, it is estimated that some 15.7 million people have been food insecure in urban areas (UN- Habitat & World Food Programme, 2021).

A Comprehensive Food Security and Vulnerability Analysis (CFSVA) conducted by the World Food Programme and Uganda Bureau of Statistics (UBOS) shows that nearly half of Ugandans (48%) were food energy deficient between September 2009 and August 2010, over a third of Ugandans nationwide had low dietary diversity, almost 5% of Ugandans had poor food consumption and a third of Ugandan children were

stunted (World Food Programme, 2013). The World Food Programme annual country report (2020) states that forty one percent of the Ugandan population is undernourished, 32 percent of women and 16 percent of men are anaemic, twenty-nine percent of children under the age of 5 years are stunted and 53 percent are anaemic and at risk of not reaching their full mental and physical potential.

The Food and Agriculture Organization (FAO) estimates that in order to meet the demand for food in 2050, annual world production of crops and livestock will need to be 60 percent higher than it was in 2006 (FAO, 2016). According to the annual World Development Report, Gross Domestic Product growth from agriculture is nearly four times more effective in reducing poverty than GDP growth from other sectors (World Bank, 2008). According to Salami *et al*. (2010) the growth of smallholder agriculture increases rural farmers' incomes, lowers their food expenses, reduces income disparity and accelerates the rate of poverty reduction.

Urban agriculture is one of the activities through which food and nutrition security is attained by growing of crops such as sweet potatoes, cassava, spinach, sukuma wiki, fruits, tomatoes, chilli peppers, onions and rearing of cattle, pigs, poultry farming and fish farming in back yards, yards and alongside public pathways and buildings, but also in the low-lying areas that drain into the lake and idle land (Flynn, 2001).Urban farming can significantly reduce livelihood vulnerability by balancing off the high cost of food in urban areas and allowing farmers to sell surplus into urban markets, thus assisting the less fortunate members of the urban society meet their needs (Bianca, 2009).Thus, stakeholders should give top priority to the livelihood of many farmers by addressing farmers' climate change and variability adaptation concerns.

Urban farming is a sector that is located inside (intra-urban) or on the outskirts (peri-urban) of a town, a city, or a metropolis that grows or breeds, processes, and distributes a variety of foodstuff and non-foodstuff products. The sector utilizes mostly the people, materials, products and facilities located within and around that urban area (Masvaure, 2015; Flynn, 2001; Bianca, 2009) as shown in plate 2.1.

Plate 2.1: Showing an urban backyard vegetable farm in Kampala District

Source: UN Habitat (2009)

2.2.2 Climate Variability

According to IPCC (2014), the phrase "climate variability" refers to seasonal fluctuations in the weather over a specific time period. The word is frequently used to describe differences between long-term data related to a certain calendar period and climatic statistics over a given time period (such as, a month, season, or year). Furthermore, Stone (2014) defines climatic variability as changes in mean state and other statistics such as standard deviation, the occurrence of climatic extremes at all time and spatial scales outside those associated with specific meteorological events. In this sense, climate variability is measured by those aberrations, which are sometimes referred to as anomalies. Therefore it can be said that climate variability refers to a situation where the climatic variables of the region deviate from the long-term average, making the climate of a locality different. As a result some years receive below mean

rainfall, temperature, or wind, while other years receive average or above average climate conditions. The current study concentrated on changes in seasonal temperatures, rainfall, and wind in Kampala district.

Atmospheric and oceanic flows, which are primarily brought on by the sun's uneven heating of the earth, have been implicated in the phenomenon of climatic variability (IPCC, 2014). The Intergovernmental Panel on Climate Change adds that the atmospheric movements occur faster than that of the ocean, but the ocean has a greater capacity to retain a large amount of heat and releases it more slowly over time so the ocean serves as a memory in this flow. Seasonal and annual climate variations are brought on by these ocean-atmospheric flows. Numerous researches on climate change and variability have been carried out in various regions.

An assessment of smallholder farmers' perceptions on climate change and climate change adaptation in Bolero community, Rumphi District in northern Malawi was conducted by Munthali *et al*. (2016). The study revealed that out of a sample size of 100 respondents, 76 percent believed that temperatures had risen while 74 percent believed that rainfall had decreased. The respondents concurred that their farming activities had been impacted by increasing exposure to climatic changes. Studies on how people perceive climate variability have given information on local climatic conditions and knowledge, bringing to the fore the understanding of the local environment and climate by the population.

Furthermore, Hepworth and Goulden (2008) note that climate change and variability in Uganda lead to increased rates of erosion, land degradation, damage to infrastructure, property and settlements, lead to decreased grazing potential, food insecurity, reduced

water supply, water borne diseases and have large micro-economic costs that slow down economic growth (Ochieng *et al*., 2020).

According to Garcia and Markandya (2015), climate variability in Kampala district is manifested in form of frequent floods, dry spells, frequent and abrupt occurrence of thunderstorms both during and outside of the wet seasons. Garcia and Markandya add that extreme climate change events leave approximately 60% of the Kampala population with less capacity to recover exposed. Authors concur that the livelihoods of smallholder farmers' in Africa and beyond are negatively impacted by the seasonal fluctuations in weather.

The UN-Habitat report (2009) notes that climate variability in Kampala is manifested in floods and decreased water availability resulting in loss of life and possessions, water contamination and outbreak of water borne diseases like cholera affecting mostly the poor. The UN-Habitat report adds that, the urban segments most susceptible to extreme weather events include: industrial facilities, businesses, communities, roads and related infrastructure, communication facilities, public transit networks, town livelihoods, ecological units and the population in general, as shown in Plate 2.2 and Plate 2.3.

Plate 2.2: Showing Flooding in Kampala

Source: Lwasa (2016)

Plate 2.3: Showing effects of flooding on the transport sector in Kampala

Source: UN-Habitat (2009)

According to IPCC (2014), the effects of climate change are anticipated to worsen poverty in many emerging nations and to generate new pockets of poverty in nations that already experience rising inequality in both rich and developing nations. Thus, climate variability if not well managed can easily compromise household assets, food availability, household income and financial independence. In conclusion, climate changes and fluctuations are expected to have a wide range of effects on different

groups of people as well as different sectors, towns, regions and countries. In order to reduce losses and enhance household livelihood, it is important to undertake measures to deal with climatic variability. Thus, adaptation emerges as one of the defensive mechanism for lessening the damage caused by climate variability.

2.2.3 Climate Variability Adaptation

The word "adaptation" describes changes made to human-environmental systems as a result of observed or anticipated climatic stimuli. The term "adaptation" can also be used to describe actions, operations and strategies implemented with the aim of lessening sensitivity to actual or expected climatic variations. Adjustments to ecological, social, or economic systems in response to existing or anticipated climatic stimuli and those stimuli's results or implications are referred to as adaptation (IPCC, 2014). Agriculture is a human-dominated environment, and as such its vulnerability is dependent not only on the biophysical effects of climate change but also on human efforts to mitigate those effects. Thus, the term climate variability adaptation involves modifications in current practices to mitigate the negative effects of climate hazards.

Akinnagbe and Irohibe (2014) point out that, coping with climate change involves making the necessary modifications and changes to lessen its harmful consequences. Adaptation objectives involve lowering the risk of harm, developing the capability to survive with unavoidable harm and exploiting fresh opportunities posed by climate variability. A critical assessment of information on Poverty Reduction Strategy Programs (PRSPs) and National agricultural adaptation plans in ASARECA member countries revealed that Uganda’s climate change adaptation strategies in terms of water and land include; collecting water from different sources (for example ground, roof, and stem drainage) using different approaches (for example municipal dams), soil

conservation by building infiltration trenches around houses, planting pasture, using the terrace farming, digging trenches for drainage, mulching and tree planting (Nzuma *et al*., 2010).

The Ugandan government is already implementing climate change and adaptation policies as well as programs that demonstrate that Uganda embraces the idea of climate change adaptation. Some of the climate policies and programs adopted include: the National Adaptation Action Programs (2007), the National Policy for Disaster Preparedness and Management (2010), National Climate Change Policy and its implementation strategy (2013), Intended Nationally Determined Contribution (INDC) (2015), Agriculture sector National Adaptation Plan (2015), 10-year Climate Smart Agriculture Program (2015-2025), the National Development Plans (2010/11 - 2014/15), and the Parliamentary Forum on Climate Change (Nyasimi *et al*., 2016). In light of climate change and variability, institutional and legislative frameworks provide guidelines and steps that governments, institutions, organizations and individuals might take to support human progress and sustainable ways of living.

Previous studies on vulnerability and adaptation have revealed the foundations for differentiating adaptations. These include: purposefulness, autonomous, spontaneous, automatic, natural; timing; anticipatory, proactive, ex-ante, ex-post, responsive; function; localized, widespread; structural; legal, institutional, regulatory, technological; performance; cost effectiveness, efficiency, implementable, equity; and a distinction between planned and autonomous adaptation (Smit & Pilifosova, 2001). The current study focused on both planned and unplanned adaptation practices adopted by smallholder vegetable farmers.

The study considered agricultural adaptation strategies suggested by Smit and Skinner (2002) that is; technological development adaptation strategies, government agricultural support programs, farm production adaptation strategies and farm financial management adaptation strategies. A wide range of options are available for agricultural adaptation such as micro level options like crop diversification and changing the timing of operations; market responses for instance income diversification and credit schemes; adaptive capacity and institutional strengthening for example developing meteorological forecasting capability, information provision, and technological developments like development and promotion of new crop varieties and integration of water management (Mubiru *et al*., 2018). Efforts to adapt to climate variability are crucial to farmers' livelihood and largely depend on farmers' capacity to adopt.

2.2.4 Adaptive Capacity

Adaptive capacity is an underlying characteristic of a person, a group, or a social, environmental system which gets triggered in response to a disaster or an opportunity and facilitates changes in behavior and technological resources (Lockwood, 2015). According to Ofoegbu *et al*. (2016), adaptive capacity is a person's ability to adjust rather than the concrete actions undertaken in reaction to unfavorable circumstances. In small-scale farming, farmers' capability to recognize as well as apply adequate practices in reaction to varying weather conditions is constrained by obstacles to implementation of better quality climate-smart know-how and actions.

Urban farmers, gardeners, and practitioners in New York city were found to be limited by a lack of financial and material resources, access to municipal programs, technical support and organizational support regarding agriculture and gardening procedures,

planning and project management, and basic business managerial skills like financial reporting and tax accounting, limited community outreach and collaboration, and disconnect from organizing and policy formulation plus race and class-based disparities (Nevin & Kristin, 2014). Thus authors recognize the usefulness of social, political, financial, and technical, material and information resources in urban agriculture.

A study on livelihood resilience and its influence on livelihood strategy in Ankang Prefecture, Southern Shaanxi Province (Liu, Li, Ren, Xu, Li &Li, 2020) aimed to improve adaptability and welfare in new locations. The authors employed principal component analysis (PCA) method and survey data were analyzed using STATA SE14.1 software. The study revealed that centralized resettlement communities lacked public supports and public service infrastructure and resettled household's social cooperative networks were difficult to establish effectively. The authors suggest that a wide range of socio-economic indicators should be taken into account to allow farmers adjust to the various characteristics and particular circumstances.

A review by Simo˜es *et al*. (2010) titled "enhancing adaptive capacity to climate change: the case of smallholder farmers in Brazilian semi-arid region" focused on Pintadas project. The objective of the project was the gradual development of a methodology for the implementation of an adaptation program for smallholder farmers in the semi-arid region. The review revealed that the Pintadas adaptation project led to increased income of participating families due to surplus production being sold on the local market, improvement in agricultural productivity, diversity of production, competency in using technology installed on family farms, efficient water use and more aware of climate change.

A study by Adebanjo (2013) employed a varimax-rotated principal component analysis to examine the key factors that limit food crop growers to adapt to climate change in southwestern Nigeria. The results showed that the main constraints to adaptation as perceived by the respondents were; long distance of household food crop farms to their homesteads, participation in off-farm jobs, subsistence production, inadequate access to climate change adaptation information, insufficient knowledge of credit source to support farm work and tiresome nature of climate change adaptation strategies and inadequate extension services.

According to Yaro *et al*. (2016) the main motivating factors for farmers to choose adaptation practices were yields, land availability and income, and those farmers who adopted adaptation measures did not experience the perseverance of the various environmental challenges resulting from climatic variability. According to Tesso *et al*. (2012), the availability of formal institutions such as input and output markets as well as household characteristics and access to information influenced farmers' adaptation decisions among farmers in north Shewa Ethiopia.

A review of 20 articles published on baseline studies in agro-ecological zones in Kenya, Uganda and Tanzania focused on climate risks and as well as adaptation techniques using a realist review method. It was reported that most smallholder farmers in target sites were constrained by limited land holdings, limiting economic profitability; weak institutional arrangements for climate changes; poor farm planning and insufficient wealth investment via borrowing or other channels (Sika *et al*., 2017).

Sorre *et al*. (2017) study on adaptive capacity among smallholder farmers in Busia, Kenya revealed that social capital is an indicator of adaptive capacity and was moderate among the respondents. The study revealed that farmers who belonged to social groups

such as one acre fund accessed information on whether rains would come early or not as well as information on the appropriate time for plating. The survey also revealed that respondents obtained farm inputs, loans, and information from organizations, learnt how to save and invest through social groups like merry go round and this boosted their adaptive capacity.

According to the Ministry of Agriculture, Animal Industry and Fisheries (2018), factors that restrict effective adaptation by smallholder farmers were; limited use of productivity enhancing inputs such as better seeds, herbicides and pesticides, irrigation equipment; land tenure, diseases and pests, unreliable rainfall, lack of technical knowledge, decline in soil fertility, insufficient labour, soil and water contamination. This means that the extent to which the impacts of climate variability are experienced largely depends on the smallholder farmers' adaptability. Nhemachena *et al*. (2010) point out that the poor especially smallholder farmers are at great risk because they have limited opportunities to diversify their resources and incomes, have limited access to land, inadequate access to water, inadequate technology, inadequate education and poor institutional mismanagement.

From the discussion on the concept of adaptive capacity, it is clear that farmer's decision to adopt climate variability adaptation strategies is dependent on a number of factors without which adaptation will not be effected. The current study examined adaptation strategies believed to influence smallholder farmers' livelihood.

2.3 Empirical Literature Review

2.3.1 Technological Development Adaptation Strategies and Livelihood of Smallholder farmers

Technological development adaptation strategies refer to both modern and local technological advances employed by farmers to cope with adverse impacts of floods, droughts and wind surges such as use of new crop varieties, water harvesting, use of weather and climate information.

According to Smit and Skinner (2002), adaptation strategies under technological development include; crop development strategies such as development of new crop varieties, meteorological and climate information systems; innovations in resource management. Technological adaptations are established via research programs conducted or sponsored by federal and provincial governments and through private sector research and development programmes. Technological adaptation measures are devised to raise tolerance and adaptability of plants to temperature, humidity and other pertinent weather conditions.

In the Bolivian Altiplano, Valdivia *et al*. (2010) examined how local responses to the uncertainties of climate change are affected by relationships among livelihoods strategies, capitals and knowledge. In order to find alternative adaptation techniques the study employed a participatory research approach to evaluate indigenous knowledge and created future climate scenarios. Findings of the study showed that communities in the central Altiplano have higher levels of human, natural, economic and social capital than those in the northern Altiplano. The survey revealed that all communities rely heavily on local knowledge of weather forecasts, the radio is a common source of information in the northern Altiplano communities and farmers are increasingly

introducing new cash crops and varieties that can be cultivated in warmer climates. The study recognizes farmers' reliance on local knowledge and radio as sources of weather forecast and climate information. The study does not examine how local responses to the uncertainties of climate change affect livelihoods.

A study by Kohli *et al*. (2016) in India evaluated climate smart technologies used by farmers in the plains of south Bihar. The study revealed that the introduction of resilient cultivars that are already well-liked by farmers such as millets in during the *kharif* (rainy) season and *lathyrus* during the *rabi* (dry) season potentially lessen the vulnerability to climate change. It also established that farmers' use resistant crops which are least reliant on foreign inputs, have decreased risk of pest and diseases, can complete their life cycle from seed to seed using only the moisture left over from the previous crop. The survey found that use of traditional water harvesting structures (the ahaar), zero or minimal tillage techniques, traditional crop establishment techniques like bhokha (direct drilling) or paira (relay cropping) which have an advantage over conventional technological practices was common. It can be concluded that farmers in south Bihar employ both modern and traditional climate smart technologies to respond to current or expected effects of climate change. The study however did not examine the impact of the technologies on farmers' livelihood. The current study also looked at technological developments such as introduction of new crop varieties, water harvesting, use of resistant crops and their effect on farmers' livelihood.

A study conducted by Diallo *et al*. (2020) evaluated southern Mali's productivity, food security and methods for adapting to climate change. It used the ordinary least squares (OLS) method. According to the study farmers used short-duration maize cultivars, modified planting dates and used organic fertilizers to reduce the adverse effects of

climate change. The study found a strong positive correlation between the adoption of short-duration crops and family food security status. It was revealed that most maize farmers who planted short-duration crops as a strategy for coping with climate change were more food secure than those who planted long-duration crops. The evaluation stresses the use of an array of technological development adaptation strategies. However, it did not establish how methods are implemented and how they impact on farmers' livelihoods. The current study sought to establish the effect of technological development studies on farmers' livelihood.

Musa and Sulaiman (2017) examined the indigenous best practices used by irrigation farmers to combat climate change in the Ajiwa and Dutsinma agro-ecological zones of Katsina State in northern Nigeria. Respondents were selected using a multi-stage sampling method and data were gathered utilizing a structured interview schedule, field observations, focus group discussions, pictures and participatory methods. The Statistical Program for Social Scientists was then used to analyze the data (SPSS). The results of the study demonstrated that farmers are knowledgeable about changing climatic conditions and have access to different sources of information. The study's findings revealed that the majority of irrigation farmers considered other farmers, friends, relatives, and neighbors to be the most reliable sources of information about climate change followed by radio, cooperative group members, open market vendors and government extension agents.

The study found that with the arrival of Islam in the study area, soothsayers' value as a source of information on climate issues had declined to the point where only a small percentage of farmers (25%) ever used their services. The study recommended intensifying the usage of information and communication technology (ICTs). The use of weather and climate information to assist farmers in coping with drought and other

climatic challenges is well acknowledged and as such is an essential component of adaptation and agricultural production.

A study by Bedmar *et al*. (2015) in East Africa evaluated the extent to which farmers are adopting climate smart practices. The study employed surveys to 298 farmers and 70 experts between November 2014 and March 2015 in Rakai in Uganda and to 302 farmers and 85 experts between July and August 2015 in Lushoto Tanzania. Data were analysed using descriptive and inferential statistics using bivariate correlation. The study revealed that climate smart technologies(CSTs) existing in the study areas were; crop pest and disease management, soil fertility management, managing diversity on the farm, water and water use management, animal/livestock management and introduction of improved and traditional crop varieties. According to the survey findings, very few farmers used the CSTs that were associated with managing crop pests and diseases, soil fertility, on-farm diversity and water production management techniques, most farmers adopted CSTs related to crops and livestock management. From the survey, adoption of new crop varieties was found to be higher among the respondents from Rakai at 24% compared to those from Lushoto at 19.5%.

The findings also revealed that the factors influencing the rates of adoption include; high associated costs, small land sizes, and a lack of awareness and sufficient knowledge about the CSTs as well as the lack of capacity in the extension systems due to an insufficient number of resources and personnel to implement demonstrations, and field schools for farmers. The survey suggests an evaluation of the suitability of technologies in the studied areas in light of costs, labour shortages, limited farm size, population pressures, and topography, raising farmers' awareness about the benefits associated with using the and the creation of learning alliances.

A study by Osewe *et al*. (2020), conducted in two regions of Kilolo and Mbarali in southern Tanzania assessed the factors impacting the use of farmer-managed irrigation and its impact on smallholder farmers' per capita net crop income. The study employed a survey research design at the household level, summing up the gross crop income from each household's agricultural farms. According to the study's findings, factors that influenced farmers' decisions to adopt irrigation practices included their experience with drought, membership in water user groups, ownership of assets, access to extension services and membership in farmer organizations, as well as the gender of household head. Using the propensity score matching to estimate the impact of adoption on net per capita income, it was inferred that the adoption of farmer-managed irrigation has a significant positive effect on smallholder farmers' net per capita income. The study recommends the government to support farmer-managed irrigation, ensure that farmer-managed irrigation practices do not hurt the environment and leverage micro services to the farmers.

In the researcher's opinion, irrigation is a vital adaptation strategy particularly in areas where food needs of a rapidly growing urban population are increasing day by day. The current study is different in a way that it looked at the association between technological developments such as irrigation strategies and livelihood in totality and not merely farmers' per capita net crop income.

A study was conducted by Ogada *et al*. (2020) in Kenya's Nyando Basin and assessed the effect of climate-smart agricultural technologies on household incomes and wealth accumulation of smallholder farmers. The study used household domestic asset index, household survey data from Kenya's Nyando Basin, statistical matching and simultaneous equation econometric modelling. Descriptive analyses show that adopters

of multiple stress-tolerant crops have superior asset indices on average, both before and after the introduction of climate-smart village (CSVs) approach. The results demonstrated that using a variety of stress-tolerant crops enhances household income by 83%, which in turn enhances household asset accumulation. The findings showed that the use of multiple stress-tolerant crops improves the accumulation of household assets through the income path. The current study sought to investigate the effect of adaptation strategies on not only household assets and income but also on household food security and knowledge acquisition and application.

A study by Gebru and Mworozi (2015) conducted in Nakasongola, Sembabule and Soroti districts and Rakai as the control district assessed climate adaptation information as well as communications needs of communities. The study employed focus group discussions, in-depth interviews, mid-line and end-line surveys with a total of 640 households in each survey. According to the study's findings, the main risks to the communities along Uganda's cattle corridor were drought, extended dry spells, unexpected rainfall and floods that resulted in the destruction of crops and livestock. According to the study, timely distribution of localized climate information and increased funding towards farmers' access to adaptation information significantly reduced crop loss and damage resulting in communities' resilience to the effects of climate variability and change. The study recommends determination of who should be responsible for paying for the distribution of weather predictions, agricultural warnings and other information related to adaptation. Such steps are essential in helping smallholder farmers increase the production of their crops and livestock thus improving livelihood. The current study looked at the sources of meteorological data in Kampala district that enable farmers to adapt to adverse effects of climate variability.

2.3.2 Government Agricultural Support and Livelihood of Smallholder Farmers

Government agricultural support may be in form of subsidies. A subsidy can be defined as any action that reduces the costs for consumers and producers through direct or indirect support (Lameck, 2016).

In Bhutan, southern Asia, a study on the socio-economic impact of agricultural subsidy program involving co-payments was conducted in six blocks representing two districts (Sonam *et al*., 2019). The study involved use of discussions with policy makers and extension workers in the agricultural sector and semi-structured interviews with heads of households. The study found that, with the exception of agricultural machineries and piglets, most households received at least one type of subsidy, the rich were more likely to receive subsidies than the poor and seed subsidies had a significant impact on income. The study also revealed that rich experienced seven and half times greater gains in income (US $2307.69) as compared to the poor (US $307.69) who also received a subsidy. It was also revealed that agriculture machinery subsidies were beneficial for higher income groups and detrimental for lower income groups (US $153.85). The study recommended providing agricultural subsidy programs and projects as a package to poor smallholder farmers, giving inputs based on existing capacities, providing technical assistance and ensuring market access. This means that subsidy provision is a way to increase resilience and livelihood of poor smallholder farmers.

A study was conducted by Shoaib *et al*. (2018) in Germany on whether service sector firms that received government Research and Development subsidies (R&D) engaged in more marketing and organizational innovation activities than their Germany counterparts. It showed that government (R&D) subsidies have a beneficial and very significant impact on organizational innovation and marketing in small and medium-

sized businesses. This finding indicates that subsidies for research and development in small and medium-sized enterprises significantly increase the likelihood of a firm to undertake marketing and organizational innovation and for large companies it has opposite but negligible benefits. These results show that because subsidies increase the likelihood of copyright applications in small and medium-sized businesses, subsidized firms are more likely to outperform their counterparts. In risk management it is crucial for governments to plan and execute policies and programs that ensure that farmers cope with the impacts of climatic changes at all times and levels. The current study did not focus on small and medium firms per se, but rather on smallholder farmers whose survival amidst climate variability is important.

In sub-Saharan Africa, a study evaluating agricultural input subsidies in four agricultural input subsidy programs in Malawi, Zambia, Ghana and Tanzania aimed at evaluating the smart subsidy program (Baltzer & Hansen, 2011). The authors focused on obtained results, hindering and enabling factors and preconditions for obtaining subsidies. The study applied the economic principles of efficiency, equity and sustainability as evaluation criteria. The findings revealed that fertilizer application by Tanzanian farmers per hectare was below the sub-Saharan Africa average of 9 kilograms per hectare of arable land and that 5.7% of rice as well as 0.7% of maize farmers used improved seed varieties and fertilizers. It was revealed that as a result of ZFSP, total maize production in Zambia increased by 146,000 tonnes in 2007/8, in Ghana total maize and rice production increased significantly in 2008 and 2009 and in Malawi the official national maize harvest increased by around 1 million tonnes in 2005/6, rising to over 2 million tonnes in the 2008/9 season compared to the 2002/3 and 2003/4 seasons. The study shows that subsidy programs increase crop production.

The current study established the value of government agricultural programs on farmers' livelihood.

In Tanzania, a study on the impact of the National Agricultural Input Scheme (NAIVS), on agricultural production in selected areas found a significant difference in welfare between households that received subsidies and those which did not receive subsidies (Lameck, 2016). The study used the panel data analysis technique to analyze agricultural data collected in 2007 (before NAIVS) and 2012 (during NAIVS). It used expenditure to represent household welfare. The survey revealed that households which had access to input vouchers had higher expenditures than those which did not have access. That significant difference in fertilizer expenditure existed where households which did not have access to voucher system spent on average less money than those households which had access to the voucher system.

In addition, it was discovered that households which accessed the voucher system had relatively higher expenditures on hired labour than those which did not. Furthermore, most poor households did not have access to the voucher system compared to relatively wealthy farmers due to high market prices of agricultural inputs. While the goal of increasing the use of fertilizers had been achieved, the goal of increasing the productivity of the poor households was not achieved. The study focused on maize farmers not vegetable farmers. The current study sought to establish smallholder farmer's access to government agricultural programs as an adaptation strategy among vegetable farmers.

A study by Sibande *et al*. (2015) in Malawi examined the effects of fertilizer subsidies on household food security and consumption expenditure. The survey estimated the conditional mean and heterogeneous effects of subsidized fertilizers using nationally

representative two-wave Integrated Household Panel Survey (IHPS) data from 2010 and 2013. It used quantile regression models to investigate the correlated fixed and random effects of subsidized fertilizers. The survey did not find any proof that subsidized fertilizers had an impact on annual per capita consumption spending. The findings also indicated that the addition of a kilogram of subsidized fertilizer increases the number of months that households are food secure by 0.2%. According to the study, fertilizer subsidies have a beneficial effect on food security. The study suggested that in order to attain long-term household food and income security, complementary policy initiatives should be promoted in addition to fertilizer subsidies. The Malawi case study results show that the fertilizer subsidy program had profound positive impacts on household food security; as a result, subsidized agricultural inputs play a vital role in resolving both persistent and new problems of poverty and food insecurity.

A study by Nuamah *et al*. (2019) in Ghana's AND district looked at the impact of extension services on rural farming communities ability to adapt to climate change. It used an interview-based qualitative case study design, the data was manually analyzed using a four-phased thematic analysis. According to the study, the district has endured increasing temperatures, damaging winds, floods, droughts, and the invasion of fall armyworms and grasshoppers. The study revealed that farmers have limited ability to adapt to climate change and thus depend on advisory services to cope with changing climatic conditions. In addition the findings revealed that extension services provide smallholder farmers with technical support and advice, knowledge and skills, new technologies, inputs and serve as a liaison with established local institutions. This study is different in a way that it looked for the association between access to government extension services and livelihood of smallholder farmers.

A study was conducted by DiFalco *et al*. (2011) in the Nile Basin in Ethiopia to assess whether climate change adaptation provides food security to farming households. A survey on 1000 farming households was conducted in 2005. A simultaneous model with endogenous switching was used. The survey found that three key factors that influenced adaptation were access to credit, extension and information. In addition, the study discovered that the food productivity function of farm households that adapted to climate change differed significantly from those farm households that did not. Furthermore, it was established that an increase in the quantity produced per hectare by farm households that adapted to climate change increased dramatically as a result of inputs including seeds, fertilizers, manure, and labor. The study suggested that research efforts be focused on identifying the most effective adaptation techniques and differentiating the roles of various adaptation strategies.

2.3.3 Farm Production Adaptation Strategies and Livelihood of Smallholder Farmers

Farm production practices involve modifications made by farmers to their farm operational procedures. The modifications may be prompted or inspired by government and industry programs. Farm production adaptations include farm-level decisions with respect to farm production, land use, land topography, irrigation, and the timing of operations. Farm production activities have the potential to reduce exposure to climate-related risks and increase the flexibility of farm production to changing climatic conditions (Smit & Skinner, 2002).

A study by Joshi *et al*. (2017) evaluated farm households' perception on climate change and adaptation practices in Rasuwa district of Nepal. The study used cross-sectional survey on 120 households in 2009. Data were gathered using structured questionnaires, focus group discussions and interviews with local government officials, buffer zone

community members and other stakeholders. The purposive sampling technique was used to select four (Daibung, Dhunche, Syaphru and Laharepauwa) village development committees, while a two-stage sampling technique was adopted to select households. Descriptive and inferential statistics were used to analyse data. The findings revealed that respondents modified harvesting time whereby in Syaphru, the harvesting time was delayed by one month in maize and potato, while it was one month early in case of wheat; in Dhunche harvesting time was delayed by 1.5 months for potato and wheat and one month for maize; in Daibung the harvesting time of wheat was one month early and one month late for maize and lastly in Laharepauwa, the harvesting time of maize, wheat and paddy was delayed by one and half months. It was also established that decisions to adopt climate change adaptation strategies are driven by factors such as landholding size, perceived threat of food security and education level. The study focused so intently on farm households' perception on adaptation practices without analyzing the adaptations' effect on livelihood of farmers.

A study was conducted by Bradshaw *et al*. (2004) in the Canadian prairies to analyze the uptake of farm-level adaptations to climate change and variability. The study employed a desk review method. The results indicated that the main adaptation options in the agricultural sector include: mixed cropping, use of different crop varieties, changing planting and harvesting dates, and mixing low yielding, drought-resistance varieties and high yielding, water-sensitive crops. In addition, it was reported that while agricultural production in Canadian Prairies relied on highly specialized monoculture cereals, which would often depend on summer fallowing to conserve moisture, farmers increasingly substituted summer fallowing and conventional tillage with extended crop rotation and conservation tillage to produce oil seeds, field peas and lentils. The study recommended that "appropriate" and even "capable" climate change adaptations need

to undergo a more thorough evaluation in order to comprehend their broader advantages and disadvantages. The current study analyzed specific farm level adaptations and established their effect on farmers' livelihood.

In Togo, Mikemina *et al*. (2018) looked at how climate change adaptation affected farmers' income in the Savanna region. Climate change adaptation decisions were modelled as a two-step framework using Ordinary Least Squares (OLS) and endogenous switching regression model. The study found that farmers' adaptation strategies in response to climate change include: crop diversification, modification of planting dates, use of irrigation, use of soil and water conservation techniques, and engaging in off-farm activities. It was also found that the income equation of farm households that adapted to climate change differs significantly from the income equation of those that had not adapted. The study revealed that farm adaptation improves the income of farm households since they would have earned about 24.08% less if they had not adopted and that adaptation strategies guarantee higher incomes even in the face of climate change as they are able to mitigate at least 63% of the impacts of climate change on crop and livestock incomes. The study was conducted in the rural Savanna region. The current study assessed the value of adaptation strategies such as crop diversification, changing of planting dates on farmers' livelihood in an urban area.

A study by Odewumi *et al*. (2013) investigated farmers' perception on the effect of climate change and variations on urban agriculture in the metropolitan area of Ibadan, the capital city of Oyo State southwestern Nigeria. Data was collected using 145 structured questionnaires administered to farmers in two major urban agricultural communities of Odogbo Barracks and Eleyele. The study utilized a descriptive survey design to select and collected both primary and secondary data. Data obtained were

analyzed using descriptive and inferential statistics. The survey found that urban farmers used four main adaptation techniques to deal with climate change and variability: use of irrigation, use of fertilizers to improve and enhance yield, practice of dry mulching as well as use of chemicals. The study also found that the coping strategies employed by the urban farmers do not differ as majority of urban farmers use the same farming production techniques**.** Therefore, it may be claimed that the type of adaptation methods to be adopted in a particular area depend on the nature of the consequences of climate variations. Thus, although the study has been conducted in urban areas like the current study, the climatic conditions and the resulting effects vary between regions and hence the variation in adaptation strategies. The current study sought to determine the location-specific adaptation tactics used by smallholder vegetable farmers in Uganda's Kampala district and their impact on farmers' livelihood.

A study by Asmare *et al*. (2019) evaluated the impact of climate change adaptation strategies on welfare of agricultural households in Ethiopia's Nile basin. It made use of data acquired in 2015 at the household and plot levels from 929 and 4778 respectively. The study used an endogenous switching regression model to measure the effect of crop diversification (CD) on the farm household's welfare, using net farm revenue and family labor demand as a welfare indicators. Survey results indicated that households that have introduced crop diversification earn much more revenue than those who have not. It also revealed that crop diversification by adopters and non-adopters can increase the welfare of households if they choose to adopt than if they do not. This study examined crop diversification as a farm level climate variability adaptation strategy and its association with livelihood of farmers.

An analysis by Gbegbelegbe *et al*. (2017) of smallholder farmers' risks, adaptation options and their impact on future adaptation programs was conducted in Kenya, Tanzania, Uganda and Ethiopia. It used a systematic review system to explain why and how complex interventions succeed or fail in the selected Agro-Ecological Zones (AEZs). The analysis revealed that reduced rainfall, higher temperatures, and unpredictable rainfall were the main climatic risks for smallholder farmers in Eastern Africa. The analysis also found that in all Agro-Ecological Zones evaluated, the most popular adaptation strategies were changes in crop management practices, such as changes in planting times, increased use of agricultural inputs and altering crop varieties, mixing long-and short-season crops and changing crop area and planting trees; better soil management, such as soil conservation practices; changes in livestock management practices and the sale of assets, such as livestock, firewood or household labour, reported in 9% of locations. The study recommends that future adaptation programs take into account differences in institutional settings between regions, develop strategies adapted to current and projected future agro-ecologies as these affect smallholder farmers' livelihoods.

A study by Mubiru *et al*. (2018) assessed farmers' perceptions on climate change, risks and coping strategies in Rakai and Hoima rural districts in Uganda. The study was based on an earlier baseline survey conducted by the Consultative Group for International Agricultural Research (CGIAR) programme on climate change, agriculture and food security in 2011 in the districts. The study also used household surveys and historical climate datasets for the period 1939-2012. The findings indicate that farmers use local innovation, improved input use and management, on-farm diversification, soil moisture conservation and soil fertility enhancement. However, the study did not examine the effect of farm adaptation strategies on livelihood of farmers. Therefore, this study

aimed to close this gap by examining the relationship between farm production adaptation strategies and livelihood of smallholder farmers.

In summary, different studies reveal that various farm production strategies are used by farmers in different areas as a way of reducing the adverse effects of climate variability on their farms. However, studies fail to establish the link between farm production adaptation strategies and farmers livelihood. For farm production adaptations to be more effective, other measures, such as finance management adaptations ought to be implemented.

2.3.4 Farm Financial Management Adaptation Strategies and Livelihood of Smallholder Farmers

A study by Manganhele (2010) evaluated government interventions to increase smallholder farmers' access to credit in Mozambique. The study collected primary as well as secondary data. The study revealed that attempts to increase smallholder farmers' access to credit in Mozambique were unsuccessful and this was attributed inability of institutions to apply prompt loan repayment procedures, political meddling and a lack of credit culture and discipline on the part of recipients. The study suggested that the best course of action for the Mozambican government to improve smallholder farmers' access to credit should include the re-establishment of a public rural bank and the adoption of a demand-driven strategy by financial institutions so they can create products that cater to a range of customers. However, the study did not examine the effect of credit access as an adaptation strategy on the livelihood of farmers. Therefore, this study aimed to close this gap by examining the relationship between farm financial management adaptation strategies such access to credit and livelihood of smallholder farmers.

Mbonane (2018) conducted a study on crop insurance preferences among maize farmers in Swaziland. The study gathered primary data through conducting surveys from 150 households in Hhohho and Lubombo regions. Snowball sampling technique was used to select respondents for the survey. Data were analyzed using descriptive statistics and binary logistic regression to identify factors that influence farmers' preferences for crop insurance. It was revealed that most respondents lacked agriculture insurance, only a small percentage of respondents were familiar with it and while some were interested in buying crop insurance others were not. The study further revealed the factors that prevent farmers from buying crop insurance including a lack of information for farmers to make insurance purchasing decisions, high crop insurance costs and willingness to manage risks on their own and distrust in insurance companies. The survey showed that farmers preferred the multi-peril crop insurance cover, higher coverage levels, lower premiums and compensation based on market price. Farmers in the Lubombo region were more interested in crop insurance than farmers in the Hhohho region. The study focused on crop insurance preferences among maize farmers. The current study assessed crop insurance as a financial management tool employed by smallholder vegetable farmers.

A study by Terfa and William (2018) on climate change and adaptation finance for farmers in northern Nigeria established the association between farmers' vulnerability to climate change and the need for financial access. According to the study, farmers in northern Nigeria are particularly vulnerable to high temperatures, extended dry seasons, and flooding all of which reduce crop productivity and revenue. The descriptive analysis showed that majority of respondents required financial support to boost poor farm harvests while a few did not, financial support was needed in form of loans to buy fertilizer, drill boreholes and buy better seedlings. Farmers in the study area needed

financial assistance to improve adaptability to shifting climate trends. The shortcoming, however, is that the study did not examine the impact of financial credit on farmers' livelihood. Therefore, this study assessed farm financial management strategies and livelihood of vegetable farmers.

A study by Awudu and Anna (2001) focused on the factors determining income diversification in Southern Mali. The study used panel data at the household level and logit model to analyze the data. It was established that non-farming revenue accounts for approximately 30% of farmers' gross income, poor households have fewer chances of engaging in non-farming activities such as animal husbandry and non-farm jobs. According to the study determinants of income diversification include; the remoteness of an area-where areas remote from local markets are more likely to engage in non-farming activities than those who live closer to local markets, education of household heads and access to financing. Income diversification means increasing the number income sources such as teaching , operating small business, brick lying, working on a construction site, fish and livestock farming (Naznin *et al*., 2015). Therefore, urban farming households adopt non-farming activities to minimize household income variability associated with climate variability, to help reduce poverty and income inequality, maximize consumption stability and improve standard of living.

In Rajshahi district, northwest Bangladesh, Naznin *et al*. (2015) assessed income diversification as a strategy to improve household wellbeing. Multi-step random sampling method was used to select 138 households in the study area. Descriptive statistics were used to analyze the socio-demographic characteristics of the respondents while multiple regression model was used to analyze the factors influencing households' wellbeing. The study also used Simpson Index of Diversity (SID) and the

welfare index to analyze income diversification data. Survey findings revealed that a majority of the population lives in rural areas with insufficient infrastructure, poor marketing amenities, poor health, sanitation and education, lack of adequate sources of income and low standard of living. The study found that the level of diversifying income in the district was very low which had a positive and considerable impact on household wellbeing. The study recommended that the government develops rural infrastructure and improves information services. The study was conducted in a rural district, the current study focused on Kampala district which is an urban area.

Yamba *et al*. (2017) conducted a study in Bosomtwe District, Ghana to establish alternative livelihood options for smallholder farmers in response to climate variability and change. The study used a cross-sectional survey on 152 smallholder farmers from 12 communities, using multi-stage sampling procedure. Quantitative data were analyzed using binary logistic regression analysis, contingency tables, and frequencies, incorporated in the statistical package for social sciences (SPSS) version 17. The survey found that due to crop failure and low yield, a majority of smallholder farmers engaged in alternative livelihood activities, whereas a minority percentage of respondents did not pursue alternative livelihood activities. The survey also found that most of the respondents in the district were engaged in small-scale trading and that coal production was the second highest alternative activity for their livelihood. Other alternative livelihood activities identified were selling cooked food, foodstuffs, small household appliances and clothes on table tops and stores. Income diversification is an important means of adapting to climate change, as it contributes to reducing the impact of climate variability on livelihoods. The study did not examine farmers' livelihoods upon using income diversification. Therefore, this study aimed to close this gap by examining the effect of income diversification on livelihood of smallholder farmers.

A study was conducted by Ndiaye *et al*. (2018) examining the impact of climate adaptation on household food security and household income in a semi-arid region of Ferlo, northern Senegal. An instrumental variable method was used to estimate the local average treatment effect (LATE). The results of the study showed that adaptation strategies were positively associated with food security of households. The study suggests that the positive impact of adaptation has an important political implication, as it could encourage the Senegalese government to take direct domestic measures to ensure food security and fight poverty. In summary, the authors agree income diversification as an adaptation option can reduce vulnerability to climate-related income loss.

A study by Ssonko and Nakayaga (2014) among farmers in Mukono District, Uganda sought to identify the function of credit in fostering economic activity. The study made use of a survey that was carried out in the six parishes of Katoogo, Bulika, Namawojjolo, Kasenge, Namubiru, and Mpoma between the months of February and March 2013. Data were analysed using binary logit model estimation. The results show that the sources of credit are government sponsored schemes, micro finance institutions, relatives and friends, private creditors, commercial banks and farmers' associations. The largest number of respondents borrowed from government-funded schemes. The results established agricultural credit schemes including; rural farmers credit scheme, start-up capital credit Scheme (*entandikwa*), poverty alleviation programme, and prosperity for all Credit Scheme (*Bonnabaggawale*). The government of Uganda has launched several schemes to support access to credit and insurance for farmers. The current study sought to establish the effect of credit as an adaptation strategy on smallholder livelihood.

2.3.5 Smallholder Vegetable Farming and Climate Change

Smallholder vegetable farming is increasing around cities in many countries. The practice has been widely commended to be a source of nutrients, vitamins, minerals, income generation and urban food security for urban residents. A major challenge facing smallholder vegetable farming is climate variability and its associated extreme events that often lead to pests and disease and low vegetable yield.

A study by Odewumi et al. (2013) in Ibadan Metropolis, South-western Nigeria assessed farmers' perception on the effect of climate change and variation on urban agriculture. The study focused on vegetable and subsistence farming in Adekunle Fajuyi Military Cantonment, Ojoo (Odogbo barracks) and Eleyele. It employed a descriptive research survey design, administered 145 questionnaire to farmers in the two areas and collected primary and secondary data.

The survey revealed that most of the farming activities within Ibadan metropolis were dominated by vegetable and subsistence farming. It also revealed that farmers perceived increase in the cost of fertilizer (32.4%), poor crop yield (22.8%) and water scarcity (20.8%) as the primary problems faced by urban farmers. The study revealed that farmers' perceived problems caused by the impact of climate variation included; outbreak of pest and disease (13.8%) and delay in harvesting or change in harvesting period (10.3%). The survey also revealed that urban vegetable farmers have long devised coping strategies such as use of irrigation, application of fertilizers, practice of dry mulching and application of chemicals to minimize the impacts of climate change.

A review paper by Hunde (2017) aimed to recognize the opportunities, constraints and potentials in Ethiopia for production of vegetables. Vegetable small-scale farmers in Ethiopia account for 90% of the agricultural output and cultivate an estimated 96% of

total cropped land. Commercial horticultural crop production is carried out mainly in the central rift valley and eastern part of the country. A recent study by Ethiopian Export Promotion Agency (as cited in Hunde 2017) identified Alemaya and Kombolcha districts in Oromia Regional State, East Shewa Woliata and Sidama zones, Dire Dawa and Harari as popular fruits and vegetables growing areas in the country .

Vegetable crops are valuable sources of vitamins, minerals and proteins especially to a country like Ethiopia where the people experience malnutrition due to heavy dependence on cereals such as tef (*Eragrostistef*), maize (*Zeamais*), wheat and other cereals. Vegetables can generate high income for the farmers because of high market value and profitability, source of food security as urbanization increases the demand for food. Vegetables are also used as source of raw material for local processing industry. Vegetables in Ethiopia have high export potential, products like tomato paste, tomato juice, oleoresin and ground spice of Capsicum are produced for exports making a significant contribution to the national economy. Most of the vegetables and fruit produced in the eastern region are exported to Djibouti and small amounts of fruit and vegetables are also exported to Europe, Pakistan, Saudi Arabia and Yemen.

The author indicates that natural factors such as inadequate rainfall, shortage of water supply, drought, flood, frost, diseases and pests, location are often beyond the control of farmers and institutions are the reasons for low vegetable productivity.

Massoma *et al.* (2005) carried out a study titled “Cabbage production in Tanzania: problems faced by smallholder cabbage growers in the management of black rot disease” in Arumeru district, northeastern Tanzania. The study identified black rot disease as the main constraint to cabbage production causing substantial crop losses of up to 100% especially during rainy seasons. Most farmers in the study area employed

chemical measures to manage black rot disease. Other management practices included; planting the crop at the right time to avoid times of heavy rain, disposing of crop trash properly after harvest, applying nitrogen fertilizer at the right rates, using certified seeds, choosing resistant cultivars, and using socio-cultural practices.

2.3.6 Urban Farming Policy in Kampala

Urban agriculture was technically illegal in Kampala even though many urban poor had been growing food for their families since the 1970s (Sabiiti *et al*, 2014). The production of food in the city is associated with health benefits and creates a green environment. However, urban agriculture can also create health hazards and damage the environment if it is not subjected to proper planning and management (KCC, 2005).

In 2005, KCC introduced five ordinances that entered into force in 2006 and established safety and sanitation requirements for urban agriculture as a legal practice contributing to food security. Sections 39 and 41 of the Local Government Act (1997) empowers local authorities to enact by-laws for regulating all activities within their areas of jurisdiction (Sabiiti *et al*., 2014). The Local Governments (Kampala City Council) Urban Agriculture Ordinance (2006) provides a legal framework for practicing urban agriculture within the city with an aim to enable residents to grow their own food legally and safely in permitted areas of the city (Sabiiti *et al*., 2014).

The new Ordinances governing urban agriculture in Kampala city include that; a person shall not engage in urban agriculture without an urban agricultural permit (Clause 3) and a valid license issued by the council; the ordinance prohibits urban agriculture in certain areas including road reserves, greenbelts, parks, places the council says are dangerous because of poisonous chemicals, areas less than 10 feet away from an open drainage channel; the ordinance also prohibits use of untreated human waste as manure,

pesticide, herbicide or fungicides that pollute the environment or cause health risks. In addition, the ordinance states that industries, vehicle operators, petrol stations and workshops should make sure that their exhaust fumes and waste products do not go into the air and water in a way that contaminates urban agriculture (KCC, 2005).

The city's urban agriculture unit was established within the city's department of production and marketing (now the department of gender, community service and production) to support and guide urban farmers and to ensure household nutrition and food security (Sabiiti *et al*, 2014).

2.4 Theoretical Framework and Conceptual Framework

2.4.1 Theoretical Framework

In this section, the researcher presents theories from development studies and other disciplines that guided the study. The theories acted as lenses through which the research findings were analyzed. Numerous researchers have developed several theories on the subject of climate variability adaptation such as the theory of change, diffusion of innovation theory, adaptive management, process-oriented approach, Sustainable Livelihoods Approach and the Action Theory of adaptation. The theories used in the study are discussed below.

2.4.1.1 Sustainable Livelihoods Approach (SLA)

The Sustainable Livelihoods Approach (SLA), more especially the Department for International Development (DFID) sustainable livelihood approach guided the study. In 1987, the Brundtland Commission introduced the sustainable livelihood (SL) in relation to resource ownership, access to basic necessities and security particularly in rural areas. According to the International Institute for Sustainable Development (IISD), sustainable livelihoods is concerned with people's capacities to generate and

maintain a means of living, enhance their well-being and that of future generations (Elasha *et al*., 2005).

Sustainable livelihood thoughts date back to the works of Robert Chambers in the mid-1980s upon realizing that conventional development concepts did not yield desired effects. According to Chambers and Conway (1992), a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable if it can cope with or recover from stress and shocks, maintain or enhance its capabilities and assets, provide sustainable livelihood opportunities for the next generation; and contribute to net benefits to livelihood at the local and global levels in the short and long term.

Three agencies; UNDP, CARE and DFID use the Sustainable Livelihood Approach however slightly differently. The United Nations Development Programme (UNDP) uses the sustainable livelihood approach primarily as a programming framework meant to devise a set of integrated support activities to improve the sustainability of livelihoods among poor and vulnerable groups by strengthening the resilience of their coping and adaptive strategies. Emphasis is put to the introduction of improved technologies, social and economic investments and addressing policy and governance issues as they impinge on people's livelihood. Support activities are organized as specific SL programmes and implemented at a district level with ramifications at the community and household level (Krantz, 2001).

CARE International on the other hand has since 1994 used the Household Livelihood Security (HLS) as a framework for programme analysis, design, monitoring, and evaluation. CARE's concept of HLS derives from the classic definition of livelihoods developed by Chambers and Conway (1992), which embodies three fundamental

attributes: the possession of human capabilities (such as education, skills, health, and psychological orientation), access to tangible and intangible assets and the existence of economic activities. The interaction between these three attributes defines what livelihood strategy a household pursues. CARE puts particular emphasis on strengthening the capability of poor people to enable them take initiatives to secure their own livelihoods. It therefore stresses empowerment as a fundamental dimension of its approach (Krantz, 2001).

Lastly, DFID uses SL framework as an analytical structure to facilitate a broad and systematic understanding of the various factors that constrain or enhance livelihood opportunities, and to show how they relate to each other. The researcher used the sustainable livelihood model of UK Department of Foreign and International Development (DFID) to frame the investigation and capture adaptation strategies and livelihood in the data collection process. The theory is based on specifying the components of a livelihood that include; capabilities, assets (including both material and social resources) and activities required for a means of living. DFID's sustainable livelihood approach aims to increase the agency's effectiveness in poverty reduction by mainstreaming a set of core principles which determine that poverty-focused development activity should be people-centered, responsive and participatory, multi-level, conducted in partnership, sustainable, and dynamic (DFID, 2000).

According to the theory, capabilities refer to the ability of poor households to perform certain activities to satisfy their needs. Assets are resources available for poor households to build their livelihoods. Activities are strategies devised and employed by poor households to meet their needs. Capitals include; human capital, labor (skills, experience, knowledge and creativity); natural capital (land, water, forests and pastures,

minerals); physical capital (houses, tools and machinery, food stocks or livestock, jewelry and farm equipment); financial capital, (money in a savings account or in an old sock, a loan or credit) ; and finally social capital,(quality of relations among people) (De Haan, 2012).

The approach claims that there are human, livestock, crop health shocks, natural hazards like floods or earthquakes, economic shocks and conflicts in form of national or international wars outside the poor person's control. The sustainable livelihood approach argues that there are institutions, organizations, policies and legislation that help the poor to shape livelihoods.

According to the theory a livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base.

The DFID approach states that the poor in a locality should not be established in advance, but should come out in the very process of analyzing livelihoods. The approach puts great emphasis on transforming the structures and processes that have the capacity to 'transform' livelihoods (DFID, 2000). The approach is presented in a diagram as shown below.

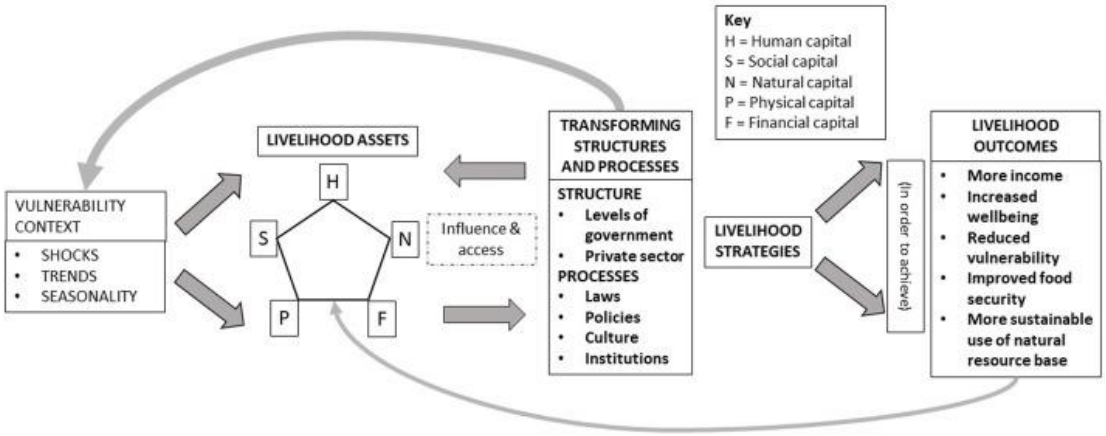

Figure 2.1: The DFID Sustainable Livelihoods Framework (SLF)

Source: Redrawn from DFID (2000).

Strengths of the DFID Sustainable Livelihood theory

It provides a useful analytical framework to understand the various factors that constrain or enhance livelihood outcomes and shows how factors relate to each other. Thus it enables understanding of the underlying causes of poverty and shows how the poorest of the poor are active decision makers, not passive victims in shaping their livelihood.

The sustainable livelihood approach offers a flexible design, is adaptable to diverse local settings. The SLA can be implemented in many different ways depending upon local context and expertise available for the analysis.

The theory is a great approach for developing indicators that help policy makers and others chart progress towards attainment of sustainable livelihood. It is also helpful in the identification of development priorities and new activities and in finding potential beneficiaries or partners in practice.

The approach has been widely used in empirical studies of livelihood strategies and adaptation (Vedeld *et al.*, 2012; Odewumi *et al*., 2013; Yaro *et al*., 2016), livelihoods and poverty (Ellis & Freeman, 2005; Salami *et al*., 2010) and livelihood diversification

(Naznin, Elias & Khairul, 2015) to assess people's livelihood assets and how the external environment of social relations, institutions, organizations, policies, seasonality, trends and shocks influence access to and ability to convert livelihood assets into livelihood outcomes.

Weaknesses of the Sustainable Livelihood Approach

The problem with the sustainable livelihood approach is that it focuses so intently on capitals, one of which is 'human', influences, institutions, policies without mentioning the people in the analysis. The approach is also criticized for not including culture in its framework even though this is an important consideration for communities and can have important impact on resources. Despite efforts to identify the various assets that influence the poor's livelihood strategies, the approach does not elaborate the elements under each category of assets and how these can be assessed.

According to the theory, participation of the poor in the analysis is key, yet the questions being asked for example asset ownership can be sensitive which can result in withholding of information. Another problem of the DFID's sustainable livelihood approach is that it is unable to predict the likelihood of occurrence of shocks, trends as it only assesses vulnerability. Despite the fore discussed weaknesses, the theory was deemed applicable to the current study because of its strong tenets pertaining livelihood strategies and livelihood outcomes.

Application of the DFID's Sustainable Livelihood Approach to the Study

The researcher used the tenets of to the theory to determine how the climate variability adaptation strategies employed by smallholder vegetable farmers sampled from the five divisions of Kampala district impacted on their livelihood goals.

The researcher also utilized the tenets of the theory to find out how the government supports the smallholder vegetable farmers in their quest to sustain their household income, household assets, food security, knowledge acquisition and livelihood structures and policies.

Smallholder urban vegetable farmers are targeted in the study and are seen to build their livelihood using a number of capitals (natural, human, financial, social and physical), capabilities and perform certain activities to meet their self-defined livelihood goals. Since the researcher was focusing on climate variability adaptation strategies and livelihood of smallholder vegetable farmers this theory was found applicable.

2.4.1.2 Action Theory of Adaptation to Climate Change

The current study was based on the action theory of adaptation to climate change propounded by Eisenack and Stecker (2010). The theory assumes that adaptation actions require actors, an intention, and resources to be used as means to address the intended ends. An adaptation is the social response by an individual, a set of individuals or an organization and only activities with an intention directed towards an impact of climate change qualify to be called adaptation actions.

The theorists claimed that adaptation actions require resources as means to achieve the intended ends. Essentially, it is not possible to implement adaptation actions without resources. According to the theory to exercise adaptation the operator needs resources, called means. The resources can be financial or other material resources, legal power, social networks, knowledge and availability of information.

The theory argues that action is further shaped by constraints and resources that cannot be controlled by the operator. The success of adaptation action depends on constraining factors and resources beyond those exercising adaptation

According to the theory there should be a stimulus, exposure unit, impact, a receptor and an operator for adaptation actions to be implemented. A stimulus is only relevant for adaptation when it influences an exposure unit who include; all those actors, social, technical or non-human systems that depend on climatic conditions, and are therefore exposed to stimuli. The theory is presented in a diagram as shown below.

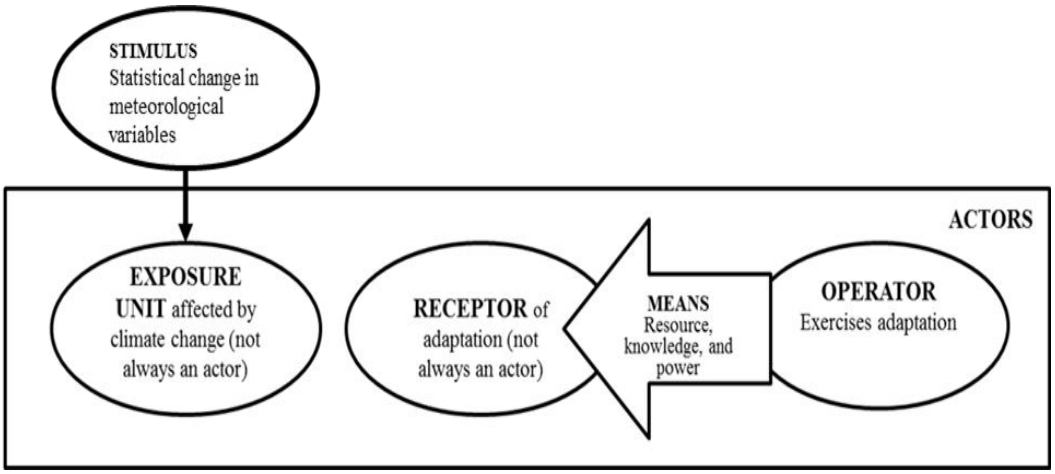

Figure 2.2: Schematic representation of some core concepts of the action theory of adaptation

Strengths of the Action Theory of Adaptation to Climate Change

The major focus of this theory is adaptation actions and the conditions necessary for adaptation. The theory provides a structure for analyzing actual or proposed adaptations, with a specific focus on the actors and institutions involved and this helps to map or deduce barriers to adaptation in a systematic way.

The theory highlights that climate change affects many actors in different ways, and that their reactions are strongly interlinked. This means that climate change poses different effects to different actors who need concerted effort to address the issue.

The theory offers an open and flexible framework adaptable to diverse ecological regions as it does not mention specific exposure units, operators, receptors and

adaptation actions. This means that the theory can be implemented in many locations depending on the magnitude of the stimulus.

Weaknesses of the Action Theory of Adaptation to Climate Change

The theory does not provides a useful analytical framework to understand how adaptation action enhances the livelihood of operators. Thus it is unable to highlight the level of success of the adaptation action in an effort to address the impact of climate change.

The other problem of the action theory of adaptation is that despite efforts to highlight the conditions necessary for adaptation such as stimulus, resources, impact, receptor and operator, the theory does not elaborate the elements under each condition. Despite the fore discussed weaknesses, the theory was deemed applicable to the current study because of its emphasis on climate change impact and adaptation action to minimize it.

Application of the Action Theory of Adaptation to Climate Change

The theory was relevant to the study because it elaborates the interplay between the stimulus, exposure unit, impact, receptor, an operator, resources and adaptation actions. This triggered the researcher to investigate on climate variability adaptations employed by sampled smallholder vegetable farmers in the divisions of Kampala district.

The other reason why the theory was used in the study was that it emphasized on the activities employed by an individual, a set of individuals or an organization with an intention directed towards an impact of climate change, and therefore, among the smallholder vegetable farmers sampled, the researcher investigated climate variability adaptation strategies employed by smallholder vegetable farmers like technological, government support, farm-level and farm financial adaptation strategies. Smallholder

vegetables farmers' main aim of adaptation action is the reduction of negative impacts of climate variability.

The researcher also utilized the tenets of the theory to find out resources required by the exposure unit. This prompted the researcher to investigate financial, technological, information and institutional resources available to smallholder vegetable farmers.

2.4.1.3 Diffusion of Innovations Theory

The theory of diffusion of innovations was propounded by Rogers (2003). According to the theory, there are four critical fundamentals that significantly influence the diffusion of innovation. These critical foundations are: the innovation itself, communication channels, time and the nature of the social system (Rogers, 2003). The theory of diffusion of innovations claims that there are five qualities that make an innovation to spread successfully and these qualities determine between 49 and 87 percent of the variation in the adoption of new products. The five qualities that make an innovation spread successfully are:

i. Relative advantage- this is the degree to which an innovation is perceived as better than the idea it supersedes by a particular group of users, measured in terms that matter to those users, like economic advantage, social prestige, convenience, or satisfaction. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption is likely to be.

ii. Compatibility with existing values and practices- this is the degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters. An idea that is incompatible with their values, norms or practices will not be adopted as rapidly as an innovation that is compatible.

iii. Simplicity and ease of use- this is the degree to which an innovation is perceived as difficult to understand and use. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understanding.

iv. Trialibility-this is the degree to which an innovation can be experimented with on a limited basis. An innovation that is trialable represents less uncertainty to the individual who is considering it.

v. Observable results- the easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Visible results lower uncertainty and also stimulate peer discussion of a new idea, as friends and neighbours of an adopter often request information about it.

According to the theory, peer -peer conversations spread adoption. The theory indicates that it's the people we personally know and trust and have successfully adopted the innovation that can give credible reassurance that our attempt to change will not lead to embarrassment, humiliation, financial loss or wasted time.

The diffusion of innovations theory claims that a population can be broken down into five different segments based on their propensity to adopt a specific innovation which include:

i. Innovators-The adoption process begins with a tiny number of visionary, imaginative innovators. They often lavish great time, energy and creativity on developing new ideas and gadgets.

ii. Early adopters- Once the benefits start to become apparent, early adopters leap in. They are on the lookout for a strategic leap forward in their lives and are quick to make connections between clever innovations and their personal needs. They love getting an advantage over their peers and have time and money to

invest. They are often fashion conscious and love to be seen as leaders, their natural desire to be trend setters causes the “take-off” of an innovation. Early adopters tend to be more economically successful, well connected and well informed and hence more socially respected. They become an independent test bed, ironing out the chinks and reinventing the innovation to suit mainstream needs and do not need much persuading because they are on the lookout for anything that could give them a social or economic edge.

iii. Early majority-Assuming the product or behaviour leaps the chasm, it may eventually reach majority audiences. Early majorities are pragmatists, comfortable with moderately progressive ideas, but won’t act without solid proof of benefits. They are followers who are influenced by mainstream fashions and wary of fads, want to hear “industry standard” and “endorsed by normal, respectable folks” as well as being cost sensitive and risk averse. They look for simple, proven, better ways of doing what they already do, require guaranteed off-the-shelf performance, minimum disruption, minimum commitment of time, minimum learning, and either cost neutrality or rapid payback periods.

iv. Late majority- They are conservative pragmatists who hate risk and are uncomfortable with a new idea, practically their only driver is the fear of not fitting in, hence they will follow mainstream fashions and established standards. They are often influenced by the fears and opinions of laggards.

v. Laggards: Meanwhile laggards hold out to the bitter end. They are people who see a high risk in adopting a particular product or behavior, some of them are so worried they stay awake all night, tossing and turning, thinking up arguments against it.

Strengths of the Diffusion of Innovations Theory

The theory of diffusion of innovations explains how innovations are taken up in a population. The theory does this by offering three valuable insights into the process of social change; what qualities make an innovation spread successfully, the importance of peer-peer conversations and peer networks and the different user segments in a population. Thus it enables development practitioners to understand the decision making process by which innovations are spread and implemented.

The theory is a great approach for initiating change in society as sees change as being primarily about the evolution or "reinvention" of products and behaviors so they become better fits for the needs of individuals and groups. The theory emphasizes that it is not people who change but the innovations themselves.

The theory offers a clear understanding of the needs of different user segments by breaking down the population into five different segments. This means that development workers are able to design appropriate programs that match the needs of the intended beneficiaries.

Weaknesses of the Diffusion of Innovations Theory

According to the theory, the spread of innovations is dependent on several qualities, yet the aspect of people participation which is very important determinant of acceptance of innovations is not mentioned which can result in resistance of innovations. It does not foster a participatory approach to adoption of a climate change adaptation strategies in agriculture.

The problem with the diffusion of innovations theory is that much of the evidence for this theory, including the adopter categories, did not originate in climate change

adaptation and it was not developed to explicitly apply to adoption of new agricultural innovations.

The other problem of the diffusion of innovations theory is that despite efforts to highlight the qualities necessary for spread of an innovation, it does not take into account an individual's resources or social support to adopt the new innovation.

Application of the Diffusion of Innovations Theory to the Study

The researcher used the tenets of diffusion of innovations theory to assess climate variability adaptation strategies as innovations and therefore, among the smallholder vegetable farmers sampled, the researcher investigated technological, government support, farm-level and farm financial adaptation strategies.

The other reason why the theory was used in the study was that it elaborates the fundamentals for diffusion of innovations. Smallholder farmers' adoption of adaptation strategies passes though similar thought processes. This means that smallholder vegetable farmers are exposed to various adaptation strategies however the choice of adaptation depends on the adaptation being introduced, the communication channels used, its timing and the social system at large.

2.4.2 Conceptual Framework

Based on the empirical and theoretical reviews the study chose a typology of adaptation strategies in agriculture suggested by Smit and Skinner (2002). The goal of the adaptation strategies is to reduce vulnerability of farmers to climate variability extreme events. As shown in Figure 2.3, the typology identifies four categories of adaptation strategies which include; technological development, government agriculture support programs, farm level and farm financial management adaptation strategies.

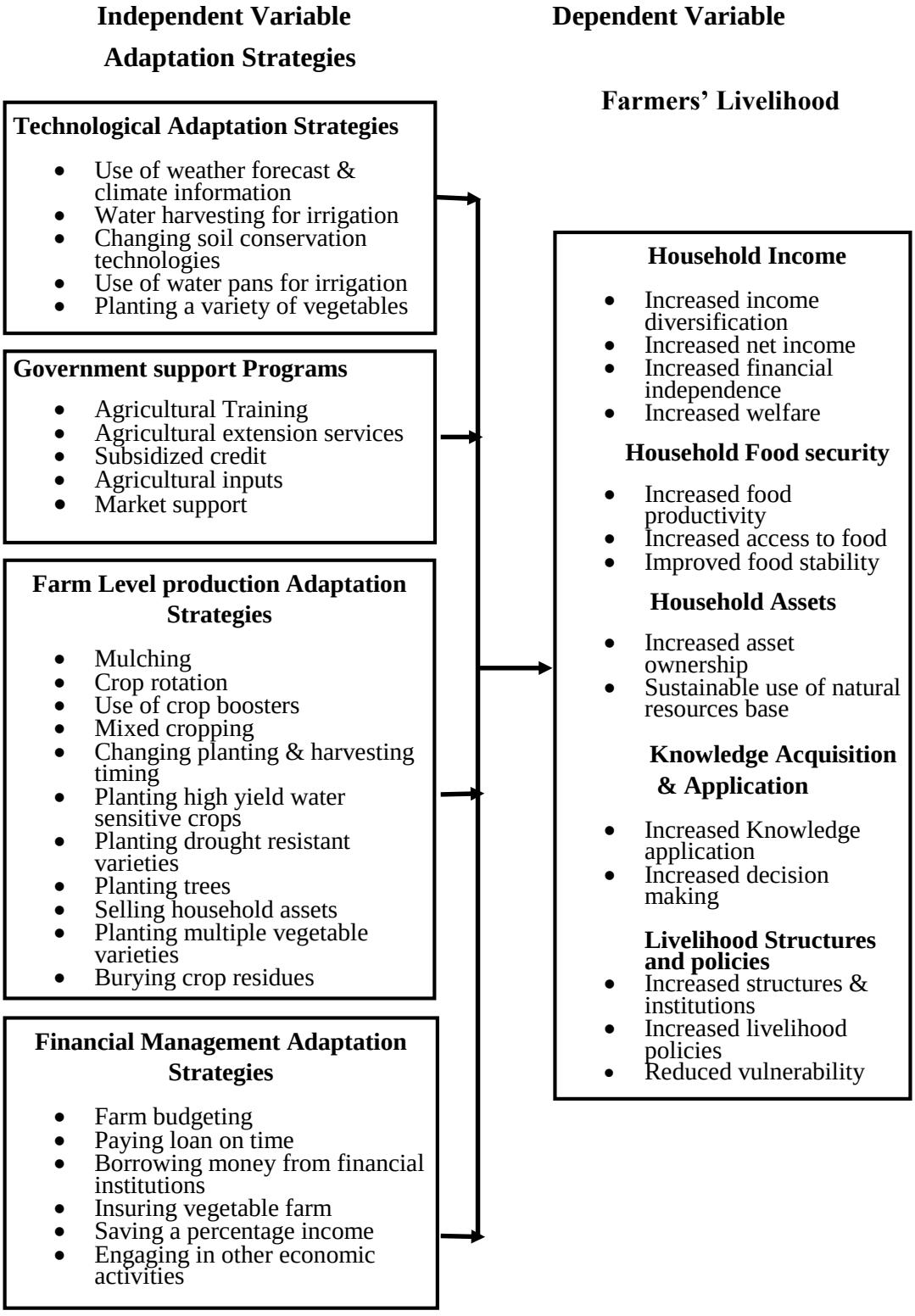

Figure 2.3: Conceptual Framework

Source: Author's Compilation (2021)

Figure 2.3 demonstrates hypothesized network of relationships between independent variables (technological development adaptation strategies, government agricultural support programs, farm level production adaptation strategies and farm financial adaptation strategies) and dependent variable of farmers livelihood (increased income, increased food security, increased household assets, reduced vulnerability, increased knowledge application and livelihood policies and structure. The interest of the study was to test if the independent variables significantly affect the dependent variable.

It is hypothesized that if smallholder farmers employ the above adaptation strategies it would lead to improved livelihood as shown in the Figure 2.3. In the long run economic, social and environmental livelihood benefits are achieved by smallholder farmers due to adoption of climate variability adaptation strategies.

2.5 Literature Review Gap

Reviewed studies focused on a variety of variables. For instance, (Aniah, Kaunza-Nu-Dem, & Ayembilla, 2019) focused on adaptation strategies used to minimize climate related risks and vulnerabilities, while (Shikuku *et al*., 2017; Muema *et al*., 2018) investigated the determinants of climate change adaptation hence the reason why the current study focused on climate variability adaptation strategies and livelihood of smallholder vegetable farmers.

Most of the reviewed studies were carried out in rural areas. For example, (Diallo *et al*., 2020) conducted a study in Southern Mali; (Ibaje *et al*., 2016) conducted their study in rural communities of Kaduna State, Nigeria; (Mikemina *et al*., 2018) did a study in the Savana Region of Togo; Ssonko and Nakayaga (2014) conducted their study in Mukono

District hence the reason why the current study was conducted in Kampala district, Uganda. According to the literature reviewed some studies focused on crops in general. For instance, (Defang *et al*., 2017; David *et al*., 2010; (Deressa *et al*., 2009) focused on crop production thus lacking crop specificity.

From the literature reviewed, different researchers targeted different populations. For instance, Manganhele (2010) targeted smallholder farmers, Mbonane (2018) targeted maize farmers whereas Massoma *et al.* (2005) targeted cabbage farmers this necessitated the current study to be conducted among smallholder vegetable farmers.

According to studies reviewed researchers employed different sampling techniques, Musa and Sulaiman (2017) used multi-stage sampling method, Mbonane (2018) employed snowball sampling technique, Naznin *et al*. (2015) used multi-step random sampling and Joshi *et al*. (2017 used purposive sampling. This prompted the current study to use proportionate stratified and purposive sampling techniques.

Some reviewed studies used a desk review method, for instance Bradshaw *et al*. (2004) and Gbegbelegbe *et al*. (2017), while Nuamah *et al*. (2019) used an interview-based qualitative case study design. This leads to absence of rich insight that a mixed method design could provide. This necessitated the current study to use an explanatory sequential mixed design. Sibande *et al*. (2015), Mikemina *et al*. (2018) used quantitative data analysis techniques, this prompted the current study to use both qualitative and quantitative data analysis techniques.

Available literature indicates that there are limited studies done on climate variability adaptation strategies and livelihood of smallholder vegetable farmers. Thus the study set out to fill this knowledge gap by attempting to understand how adaptation strategies

affect the livelihood of smallholder vegetable farmers in the Kampala district. This is vital in building farmer's resilience and thus sustainable urban livelihood.

2.6 Chapter Summary

Climate change and variability is happening worldwide and it is affecting the way of life of impoverished farming communities who are already on the verge of destitution. It is perhaps the most serious threat to the realization of Sustainable Global Goals on ending poverty, ending hunger, reduced inequalities, sustainable cities and communities.

This chapter reviewed literature on the concept livelihood, climate variability, climate variability adaptation and adaptive capacity. Reviewed literature showed that urban vegetable farming is a livelihood strategy employed by mainly the urban poor who have limited survival opportunities. Most of the literature reported that urban vegetable farming reduces vulnerability, helps farmers meet basic needs, and is a source of food and nutrition. Reviewed literature also showed that despite its significance, urban vegetable farming is faced with the problem of climate variability that is manifested in form of increased temperature, decreased precipitation in some areas and frequent occurrence of flooding and decreased water availability.

In addition, empirical literature was reviewed based on study objectives. The empirical literature showed that various studies have been conducted on technological, government, farm production and farm financial adaptation strategies. Reviewed literature on technological development adaptations reported use of climate smart technologies, new crop varieties, weather forecast and climate information and use of resource innovations.

Literature reviewed on government support programs indicated that the poor benefited more from government support compared to the poor. Government support programs reported included; research and development subsidies, agricultural inputs subsidies and extension services.

Most literature reviewed pointed to farm level production practices used in various study areas such as crop management practices like mulching, application of organic fertilizers and pesticides, use of mixed cropping, crop rotation, irrigation, crop diversification and changing of planting and harvesting dates.

Empirical literature reviewed points to farm financial adaptations such as use of credit from financial institutions and government credit schemes, use of crop insurance, and income diversification. Literature also showed that farmers face challenges in an effort to implement farm financial adaptation strategies.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter presents the study design and the specific methods adopted. The chapter includes; the area of the study, research design, research paradigm, research approach, target population, sample size and sampling procedure, data collection techniques. It provides more details on the validity and reliability of the research tools, the procedures employed to collect data, the techniques used to analyze data and ethical considerations.

3.2 Study Area

The study was carried out in Kampala District Uganda which is a rapidly growing and sprawling district in addition to being the capital and largest city of Uganda. Kampala district was chosen because its urban agriculture systems play an important role in providing nutrient dense-foods such as vegetables that cannot be readily transported from rural locations because of challenges such as inadequate transport and cold storage facilities.

Kampala district covers an area of 839 km^2, is bordered by Mukono to the east, Wakiso to the west, Buikwe to the south and Luwero to the north. It is administratively divided into five boroughs: Makindye, Nakawa, Rubaga, Kawempe, and Kampala central. As shown in Figure 3.1, the district is situated in the center of the region on the northern shores of Lake Victoria (Sabiiti *et al*., 2014)

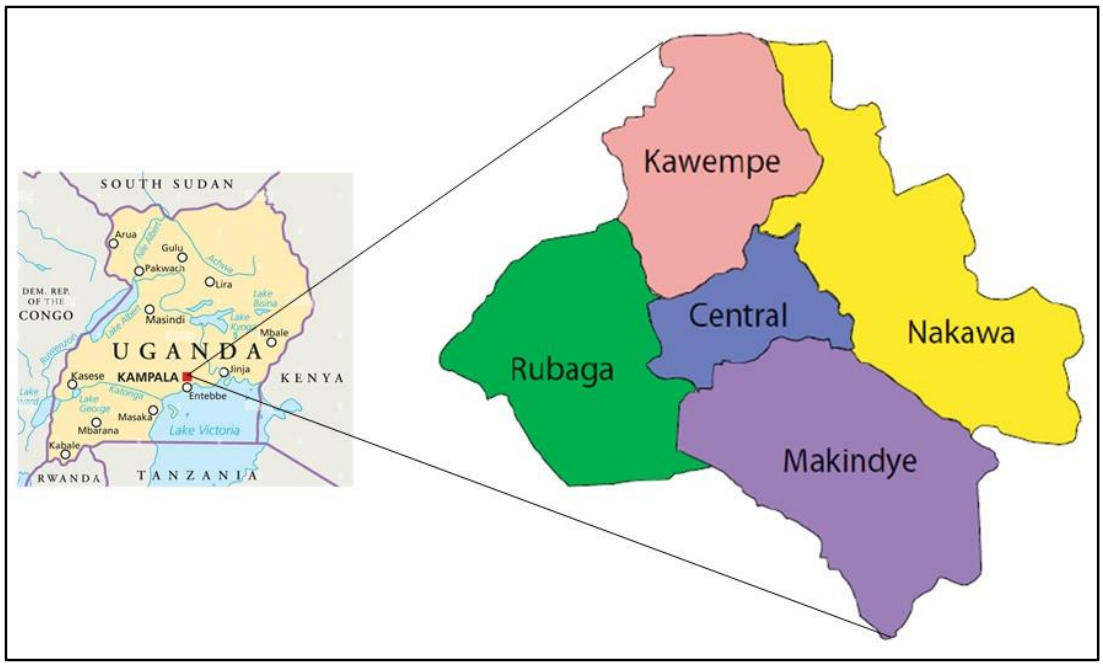

Figure 3.1: Map showing the area of study

Source: Adopted from *Rugadya (2007)*

Kampala is surrounded by a wetland valley and is perched on 24 low, flat hills at an altitude of 1120 meters above sea level (KCCA, 2016). The Kampala district has a total population of 1,507,080 people, a population density of 7,928 people per square kilometer, an average household size of 4, and 61 percent of individuals live in unofficial housing (locally known as muzigo) (Uganda Bureau of Statistics, 2016).

Kampala district receives a bimodal rainfall pattern averaging 1,290 mm, March to May is the main rainy season peaking in April whereas October to December forms the secondary rainy season (KCCA, 2016). Rainfall in Kampala is anticipated to peak around the middle of October and end in the early days of December. As shown in Figure 3.2, the driest month is July, and the average temperature is always high. The average annual temperature is 21.3 °C. With a secondary dry season in June and July, the primary dry season lasts from December to February (Uganda National Meteorological Authority, 2020).

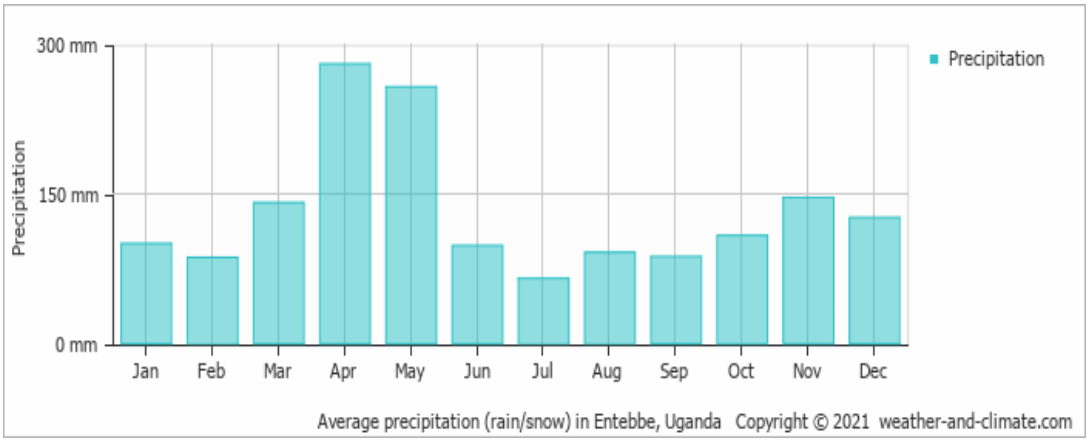

Figure 3.2: Showing Temperature and Rainfall data for Kampala District

Source: Adopted from Uganda National Meteorological Authority (2020)

Kampala district is blessed with abundant natural resources such as land which makes it suitable for agriculture as shown in plate 3.1. According to Sabiiti *et al*. (2014) more than 35% of the city population practices some form of small-scale agriculture in urban and suburban areas. As far as distribution for agricultural land is concerned, Nakawa division occupied 35%, Makindye 24.5% and Kawempe 20.6%, other land uses in Kampala district include built-up areas and industrial activities.

Plate 3.1: Showing Urban Agriculture in Kampala District

Source: Adopted from Sabiiti *et al*. (2014)

3.3 Research Paradigm

A research paradigm is a way to thinking about and conducting research; it is a research culture with a set of beliefs, attitudes, and assumptions that a community of researchers shares regarding the nature and conduct of research (Antwi & Hamza, 2015). A paradigm according to Punch (2014), is a system of fundamental assumptions (or metaphysics) relating to ultimates or first principles. The study used a pragmatic research paradigm. The pragmatic paradigm offers the possibility to use a variety of methods, different worldviews, different assumptions, as well as different types of data gathering and analysis in a mixed methods study (Creswell & Creswell, 2018). Therefore, it can be argued that the pragmatic research paradigm offers the core philosophical basis for mixed methods research. Pragmatism believes that the research question is "central" and therefore the methods of data collection and analysis are chosen as those that can best provide information on the issue without philosophical allegiance to any competing paradigm (Creswell & Creswell, 2018). In the current study, pragmatic research paradigm was used because the study employed a mixed method approach in which different forms of data collection and analysis were employed. The pragmatic paradigm was useful because it enabled the researcher to comprehend the research question using quantitative as well as qualitative data collection and analysis methods. An understanding of the research problem was deemed crucial in the current study.

3.4 Research Design

A research design establishes the researcher's position and serves as the foundation of an investigation. According to Punch (2014) a design's function is to place the researcher in the empirical setting and establish a link between the research questions and the available information. According to Creswell and Clark (2011), six broad

mixed-methods designs are recommended since they offer a helpful framework for researchers working on the design of their studies. These include; convergent parallel design, explanatory sequential design, exploratory sequential design, embedded design, transformative design and multiphase design. Specifically, this study employed the explanatory sequential design in fulfilling the philosophical paradigm. The choice of the design was guided by the necessity to employ the qualitative strand to clarify the statistical findings in the initial quantitative phase.

Explanatory sequential design begins with the collection and analysis of quantitative data, which has the highest priority to answer the study's research questions, followed by the subsequent collection and analysis of qualitative data (Creswell & Creswell, 2018). This means that priority was given to the quantitative data and that the results are integrated during the interpretation phase of the study. The explanatory sequential design involved two phases. In phase one the researcher collected and analysed quantitative data, this was followed by identification of results for follow-up. Phase two involved collection and analysis of qualitative data, and was followed by interpretation of results-how qualitative explains quantitative. Figure 3.4 depicts the process followed in explanatory sequential design and as evident from the figure, the process involved a number of steps.

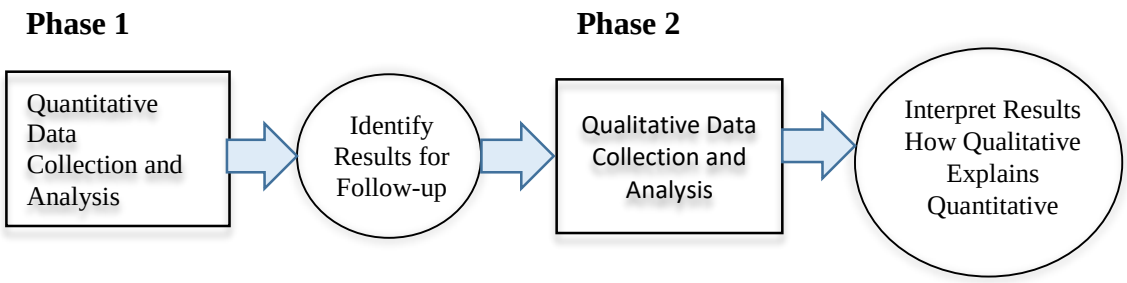

Figure 3.4: The process of explanatory sequential design

Source: Adopted from Creswell & Creswell (2018)

According to Creswell and Clark (2011), the explanatory sequential design has several benefits for instance the design is appealing to quantitative researchers because it frequently starts with a strong quantitative orientation; its two-phased structure makes it simple to implement because the researcher uses the two methods in separate phases and only collects one type of data at a time; and the final report can be written with a quantitative section followed by a qualitative section thereby providing a clear delineation for the readers. The design lends itself to emergent approaches where the second phase can be designed based on what is learned from the initial quantitative phase.

3.5 Research Approach

The study used a mixed research approach that combined both qualitative and quantitative techniques.

3.5.1 Quantitative Research

Punch (2014) noted that early social scientists set out to imitate natural scientists' use of scientific methods like experiment and measurement in building knowledge. The quantitative research tradition is associated with a positivist paradigm that has its roots in the natural sciences. Punch adds that quantitative research is equivalent to empirical research in the positivist tradition, which is centered on experimental design and statistical techniques like multiple regression and structural equation. While qualitative research applies to phenomena that can be represented in terms of quality or kind, quantitative research is applied to phenomena that can only be described in terms of quantity (Kothari & Garg, 2014).

3.5.2 Qualitative Research

Since the late nineteenth century and throughout the twentieth century, qualitative research methodologies such as grounded theory, conversation analysis and discourse analysis have evolved, expanded and proliferated in the Social Sciences. Qualitative researchers collected opinions of subjects through interviews, observation and intermediate testimonials (Ormston *et al*., 2014).

3.5.3 Mixed Methods Approach

The use of mixed methods approach dates back to the late 1980s, with the advent of several publications aimed at describing and defining the so-called mixed methods (Creswell & Clark, 2011). A mixed methods approach is a research methodology that involves gathering, analyzing and combining quantitative as well as qualitative research into a single scientific study or a longitudinal research program (Creswell & Creswell (2018). In particular, this study followed a mixed-methods research approach by mixing components of both qualitative and quantitative research approaches. A mixed approach was chosen because of its strength of drawing on both qualitative and quantitative research and minimizing the limitations of both approaches. This ensured that there were no information gaps.

According to Creswell and Clark (2011) both quantitative and qualitative methods are insufficient by themselves to collect data on variables of the study. Thus mixing qualitative and quantitative methods in research is becoming common because research problems are so complex that they require answers that go beyond mere numbers and words. Because different research methodologies have varied advantages and disadvantages, a mixed approach aids to improve the quality of research, minimizes the

likelihood of missing important information, has the potential to foster theory building and offers new tricks for collecting data (Wu, 2012).

Instead of the usual association of specific paradigms with quantitative and qualitative research, the mixed methods approach tends to encourage the use of numerous world views, provides more evidence of studying a research problem than either quantitative or qualitative research alone, allows exploration of qualitative ideas and generalization from quantitative strand, and allows the limitations of one method to be balanced by the strength of the other method (Creswell & Clark, 2011). Mixed method procedures have been created and improved to address a variety of research problems (Creswell & Clark 2011). The research is based on the premise that collecting different types of data provides a better understanding of the research question than qualitative or quantitative data.

3.5.3.1 Application of Mixed Methods in the Study

In addition to outlining the steps involved in mixed-methods research, Creswell and Clark (2011) emphasized the significance of timing, weighting, and mixing. These are further detailed below on how they were used in the study.

3.5.3.1.1 Timing

Timing refers to when the data were gathered (Creswell & Clark, 2011). Data were gathered in a sequential manner, with the quantitative component preceding the qualitative component (QUANT qual). Prior to gathering, analyzing, and interpreting qualitative data, the researcher first gathered, analyzed, and interpreted quantitative data. In this study the implementation of the qualitative component depended on the findings of the quantitative component's data analysis. Questionnaires were designed and used in the first quantitative phase, and then interviews were conducted in the

second qualitative phase, while observations were made across the two primary methods of collecting the data mentioned above. Separate analyses were carried out to preserve the accuracy of the findings.

3.5.3.1.2 Weighting

This relates to prominence given to the various methods in this study. Capital letters are frequently used to emphasize the importance of the dominant approach (such as QUAL or QUAN), whereas smaller letters are used to denote less prominent methodical approaches (qual or quan). But it is conceivable to give both traditions equal weight, in which case both are written in capital letters (QUAL and QUAN). Data weighting decisions may depend on one's epistemological perspective as well as practical considerations like data access and data formats (Creswell & Clark 2011). In this study, the quantitative approach had more weight than the qualitative approach. The quantitative component was more suitable for measuring adaptation strategies and livelihoods and for studying their statistical relationship. It was the most appropriate to answer the research question compared to the qualitative approach.

3.5.3.1.3 Mixing

According to Creswell and Clark (2011), data for research can be combined during data collection, analysis, and interpretation or combined in all the three stages. It can be combined by incorporating one data type into another, altering and/or combining two different or separately presented data types and then combining them to answer specific research questions. This study combined data from both approaches when presenting and interpreting the results.

3.6 Target Population

A target population represents all members of the real group of individuals, occasions, or things that the researcher desires to generalize the findings of the study (Pandey & Pandey, 2015). As shown in Table 3.1 and Table 3.2, the study's target population consisted of 1083 smallholder vegetable farmers in the five boroughs of Kampala district namely; Nakawa, Rubaga, Kawempe, Makindye and Kampala Central. According to KCCA (2016), there are 1083 registered smallholder vegetable farmers in the district all of whom were targeted in the study. In addition, the study targeted 10 key informants who included; 5 NAADS officials one from each division and 5 KCCA officials from the department of gender, community services and production. The purpose of including the key informants in the study was to ascertain their role in farmers' adaptation efforts.

Table 3.1: Target Population of Smallholder Vegetable farmers per Division

Division	Total population
Nakawa	301
Rubaga	152
Kawempe	255
Makindye	305
Central	70
Total	1083

Source: KCCA (2016)

Table 3.2: Target Population of NAADS and KCCA Officials

Key informants	Population size
KCCA officials	5
NAADS officials	5
Total	10

Source: KCCA (2016)

3.7 Sample Size and Sampling Procedure

3.7.1 Sample Size

From the target population of 1083, a sample of 292 vegetable farmers was picked. This was determined according to the Yamane (1967) formula (as cited in Ngigi *et al*., 2016). The formula was used to determine the sample because the population of the study was finite and was known.

The formula is:

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

Where *n* is the sample size

N is the population size,

1 is a constant and

e is the sampling error.

Since there are 1083 smallholder vegetable farmers in Kampala district, then the sample was calculated as follows:

$$Thus\ n = \frac{1083}{1+1083(0.05)2)}$$

$$n = \frac{1083}{1+1083*0.0025} = \frac{1083}{1+2.7075}$$

$$n = \frac{1083}{3.71} = 292$$

The computation therefore, led to a sample size of 292 smallholder vegetable farmers. In addition, 10 key informants who included: 5 NAADS officials and 5 KCCA officials were also included in the sample.

3.7.2 Sampling Techniques and Procedures

The sample size of 292 vegetable farmers was proportionately subdivided into five divisions of Kampala District in order to ensure proper and equal representation. As shown in Table 3.3, the sample for each division was computed at a proportion of 27% of the total sample.

Table 3.3: Proportionate Stratified Sampling of Smallholder Vegetable farmers in Five Divisions

Division	Farmers	Sample Size
Nakawa	301	81
Rubaga	152	41
Kawempe	255	69
Makindye	305	82
Central	70	19
Total	1083	292

Source: KCCA (2016) and Author (2021)

Simple random technique was then used to choose smallholder vegetable farmers for each division using the lottery method. The researcher wrote down farmers' identification numbers on pieces of paper, mixed them properly and picked numbers (sample) for each division. Simple random technique guaranteed that each member of a certain division had an equal chance of being chosen.

Purposive sampling technique was employed to select the 10 key informants from KCCA and NAADS. The researcher selected the individuals on the basis of personal judgement about those who were most useful and representative. The technique enabled

the researcher to locate individuals with rich information on the issue of climate variability, adaptation strategies and livelihood of vegetable farmers.

3.8 Data Collection Techniques

In order to gather both quantitative and qualitative data for the study, questionnaires, interview schedules, and observational guides were used. The study's data was collected sequentially, starting with quantitative data and then qualitative data.

3.8.1 Questionnaires

Semi-structured questionnaires were used to collect quantitative data from smallholder vegetable farmers. Questionnaire technique is associated with being economical, time saving, covers research in a wide area (Pandey & Pandey, 2015). There were closed-ended questions with a Likert scale in the survey. This ensured uniformity of responses thereby making data processing very easy. In addition, Likert scale has a proven strong psychological benefit, measures gradations in opinions, behavior, attitude of respondents, has the ability to measure multiple items as well as complex and multi-dimensional values thereby addressing ‘random’ error at the same time (Johns, 2010). A 5-point Likert scale with the following responses was used to elicit responses: 1-strongly disagree, 2-disagree, 3-moderately agree, 4-agree, and 5-strongly agree.

A questionnaire was prepared basing on the study’s variables as shown in (Appendix VI). Section A of the questionnaire contained background information seeking questions; section B solicited data on smallholder farming characteristics; section C solicited data on climate variability; while section D contained questions on technological development adaptation strategies; section E on government agricultural support programs; section F on farm level production adaptation strategies; section G

on farm financial management adaptation strategies and lastly section H solicited data on farmers livelihood.

The questionnaire was designed in English however, the survey was conducted in Luganda language to avoid any potential misinterpretation of the questions in the survey. An external professional translator was consulted to translate the questionnaire from English into Luganda in which the survey was conducted.

3.8.2 Interview Schedule

The researcher used an interview schedule as shown in (Appendix VIII) to gather qualitative data from ten (10) key informants. The key informants were purposively selected because they had a clear understanding of the climate variability adaptation strategies and livelihood of smallholder vegetable farmers. The interviews were conducted by the researcher on various dates and at various times depending on prior appointment with key informants. The interview schedule was used because it provided additional information to what had been collected through the questionnaires. According to Lune and Berg (2017), interviews are useful in eliciting the subjects' thoughts, opinions and attitudes about study-related issues. The interview schedule provided insights into the incidence of climate variability, actual adaptations employed by farmers and role of NAADS and KCCA's department of gender, community services and production in promoting farmers' adaptation practices and livelihood. Data obtained from interviews were recorded by the researcher through note taking.

3.8.3 Observation Guides

These were used to remind the researcher of the key points of observation and topics of interest. The observation guide helped the researcher to observe farmers adaptation strategies and incidences of climate variability. Babbie (2010) notes that "by going

directly to the social phenomenon under study and observing it as completely as possible, researchers can develop a deeper and fuller understanding of it" (pp.296). The main goals of observation were to provide an internal validity check from a second source of ethnographic data for corroboration, to give first-hand situational reports occurring on the ground that could escape the researchers using other methods. The researcher was able to observe the actual situation of urban gardens because she had established specific items to be observed as shown in (Appendix IX)

3.9 Validity and Reliability of Research Instruments

3.9.1 Validity of Research Instruments

Fundamentally, validity means "measuring what is meant to be measured" (Taherdoost, 2016). With the use of content validity, the questionnaire's validity was evaluated. According to Taherdoost (2016) content validity is the subjective agreement among experts that a scale seems logical to reflect accuracy of what it is intended to measure and it is attained by ensuring the relevance of the study findings with theoretical frameworks and literature reviews (Saunders *et al*., 2016). The researcher ensured content validity through use of expert judgment, extreme care in choosing the content from a variety of literature, taking into account professional perspectives, having conversations with supervisors, and consulting with KCCA authorities. Their recommendations and feedback served as a foundation for the research items' modifications, which made them suitable for the study.

Secondly, construct validity of the instruments was also examined. The term "construct validity" describes how well a concept, idea, or behavior that is a construct is translated or transformed into a functioning, and operational reality (Taherdoost, 2016).

Specifically, the researcher gave the operational definitions of all constructs and also defined indicators of each construct as used in the study.

The instruments' face validity was also confirmed. The term “face validity” refers to that quality of an indicator that makes it seem a reasonable measure of some variable (Babbie, 2010). The researcher ensured face validity by continuously revising, and reviewing the questionnaire.

3.9.2 Reliability of Research Instruments

A research instrument's reliability is determined by how consistently it produces results or data after numerous trials (Taherdoost, 2016). Researchers must critically evaluate whether the instrument is likely to consistently and accurately measure what it should measure, regardless of the research approach and method used. Reliability tests aim at ascertaining the degree to which data collection techniques, such as questionnaires and analysis procedures return dependable findings (Saunders *et al*., 2016). In this study, reliability was established using a pilot study to verify the consistency of the independent and dependent scales for the research variables. A pilot study is a strategy used to test the questionnaire with a smaller sample size than the planned sample size (Sincero, 2012).

The questionnaire was tested on twenty-nine respondents in Entebbe Municipality, Wakiso District. The researcher’s decision to sample 29 smallholder vegetable farmers was guided by Kothari and Garg (2014) principle that the pilot study involves 10% of the sample population. In Wakiso district, half of the population lives in urban areas and the climate is warm and wet with relatively high humidity like in Kampala district. The pilot study made it possible to modify vague and insufficient items in the questionnaire, to improve the quality of the research instrument and thus increase its

reliability. It also contributed to planning of the main study, the identification of probable risks and the research economy. The results of the pilot study helped the researcher revise the questionnaire to ensure that it covered the study objectives.

The data obtained from the pilot study was coded in SPSS and a reliability analysis was done using Cronbach's alpha coefficient. The coefficient was calculated for each item to determine the reliability of the research tool. It is noted by Cho and Kim (2015) that Cronbach's alpha is the most frequently used reliability coefficient. The results as shown in Table 3.4 revealed that the Cronbach's alpha coefficients of the studied variables were as follows: technological (0.790), government support (0.767), farm production was (0.772), financial (0.804), livelihood (0.863), and overall, the Cronbach's coefficient Alpha was 0.800 from 41 items.

Table 3.4: Reliability Index

Items	Cronbach's Alpha	No of Items
Technological adaptation strategies	.790	5
Government support programs	.767	5
Farm production adaptation strategies	.772	11
Financial adaptation strategies	.804	6
Livelihood	.863	14
Mean	.800	41

Source: Author's Compilation (2021)

The findings showed that all the variables taken into consideration had Cronbach's alpha (α) coefficient greater than 0.7. To be accepted as a good level, the Cronbach's alpha (α) coefficient used for reliability test value must be higher than 0.7, a Cronbach's alpha that is closer to 1 is desired because it indicates that the scale items have good internal consistency (Cho & Kim, 2015). A Cronbach's alpha reliability of at least 0.7 or above was assumed to reflect the internal reliability of the instrument.

3.10 Data Collection Procedures

The process of data collection started by seeking approval from the School of Arts and Social Sciences, Moi University to go to the field as shown in (Appendix X). Upon approval, the researcher sought research ethics approval from Makerere University School of Social Sciences research ethics committee. Thereafter, the researcher applied for a permit to carry out the study from the Uganda National Council for Science and Technology (UNCST) as shown in (Appendix XII) and an authorization letter from the Director of Administration and Human Resource Management, Kampala Capital City Authority (Appendix XI). Further, the researcher also sought approval from the National Commission for Science, Technology and Innovation (NACOSTI) as shown in (Appendix XIII). This helped in accessing climate adaptation and livelihood information from Kenyan libraries.

Upon receiving these approvals, the researcher visited the five divisions of Kampala district under the study and informed the Local Council (LC) chairpersons about the study by presenting both the research permit and authorization letter from KCCA. The researcher then identified and trained research assistants in order to acquaint them with objectives and purpose of the study and the research instruments. This was followed by visits to smallholder vegetable farmers by the researcher and the research assistants to inform them of the purpose of the study, seek their consent and to collect data. The data were collected using questionnaires, hand-delivered to farmers and administered by the researcher with the help of research assistants.

The researcher also visited farming households with an observation checklist to observe climate variability adaptation practices. The researcher also observed extreme weather events and their effects on vegetables gardens. This informed on the application of

adaptation strategies and incidences extreme weather events. Field notes from observation were recorded through note taking and photography.

The collection of qualitative data started with the researcher booking appointments with the key informants through telephone. Interviews with key informants were conducted at their place of work for convenience purposes. Each participating key informant was interviewed for twenty minutes and information obtained were recorded through note taking.

3.11 Data Analysis

3.11.1 Quantitative Data Analysis

Using SPSS version 26, the collected data was cleaned and organized. This involved identifying incorrect and incomplete responses and then fixing them to raise the caliber of the responses. Data analysis employed both descriptive and inferential statistics. Descriptive statistics included the use of frequencies, percentages, means, and standard deviation. Inferential statistics included the use of Pearson's product correlation coefficient to determine the correlation between each adaptation strategy and livelihood of smallholder farmers and multiple regression analysis was used to determine the effect of climate variability adaptation strategies on smallholder farmers' livelihood. The multiple regression model used is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

Where;

Y= Livelihood

X_1 = Technological development adaptation strategies

X_2 = Government agricultural support programs

X_3 = Farm production adaptation strategies

X_4 = Farm financial management adaptation strategies

ε = error term

β_0 = Constant coefficient of the model

$\beta_{1.....}\ \beta_4$ = regression coefficients of explanatory variables

3.11.1.1 Assumptions of Multiple Regression

Analyses using regression determine whether one or more predictor variable(s) account for the dependent (criterion) variable. Multiple regressions are parametric statistics used when the data conforms to the assumptions of normality, linearity, multicollinearity, autocorrelation, and homoscedasticity (Tabachnick & Fidell, 2019). Thus, diagnostic tests such as linearity, normality, multicollinearity, autocorrelation and homoscedasticity tests were carried out to ascertain the appropriateness of the model.

Normality: In regression, normal distribution of data for the variables are assumed. Relationships and significance tests can be distorted by non-normality distributed variables (extremely skewed or kurtosis variables, or variables with significant outliers). In the present study, quantile-quantile (Q-Q) plots were used to analyze the normality of the data distribution. Loy, Follett and Hofman (2015) observe that Q-Q plots have the ability to point out non-normal features of distributions, making them more suitable for testing normality.

Linearity: estimate the relationship between dependent and independent variables when the relationships are essentially linear (Tabachnick & Fidell, 2019). When the relationship between the independent variables and the dependent variable is not linear, the results of the regression analysis underestimate the true relationship (Osborne & Waters, 2002). Pearson's correlation coefficient was used to test for linearity. The Pearson correlation coefficient, abbreviated as *r*, ranges in value from -1 and 1. The

linear relationship between the two variables is stronger the further r is from zero. The direction of the relationship is indicated by the sign of r. When *r* is positive, then as one variable increases, the other tends to increase. When r is negative, the tendency is for one variable to increase as the other decreases. A perfectly linear relationship (*r*=-1 or *r*=1) means that one of the variables is perfectly described as a linear function of the other (Williams, 2015).

Multicollinearity: Multicollinearity describes a situation where two or more explanatory variables in a multiple regression model behave substantially linearly. Multicollinearity can be tested using three central criteria: Correlation, Tolerance and Variance Inflation Factor (Osborne & Waters, 2002). The variance inflation factor was used to examine multicollinearity. The effect of collinearity among the variables in a regression model is measured by the variance inflation factor (VIF). The variance inflation factor (VIF) is 1/tolerance. The VIF value should be less than 10, a value greater than 10 denotes the presence of multicollinearity, and a tolerance of 0 to 1 is appropriate (Williams, 2015). The correlation coefficient between a factor and itself is always 1 hence the principal diagonal of the correlation matrix is filled with 1s. This implies that it is an identity matrix and that there is no multicollinearity (Kothari & Garg, 2014).

Autocorrelation: When the residuals are not independent of one another, autocorrelation happens (Tabachnick & Fidell, 2019). The Durbin-Watson test was used to examine the linear regression model for autocorrelation. Dubin Watson test presupposes that numbers between 0 and 4 imply no autocorrelation. If the d-statistic is greater than 0.05 the study fails to reject the null hypothesis at both the 95% and 90% significance levels, indicating that the errors in the various data were not correlated with each other (Durbin & Watson, 1971).

Homoscedasticity: Homoscedasticity explains a state where the error term—the "noise" or random disturbance in the relationship between the independent variables and the dependent variable is the same for all the values of the independent variable. According to McDonald (2017), when the magnitude of the error term differs between the values of an independent variable, heteroscedasticity (the violation of homoscedasticity) is present. Scatter plots were visually inspected to see whether homoscedasticity existed between the study variables.

Hypothesis Testing

A hypothesis may be defined as a proposition or a set of proposition set forth as an explanation for the occurrence of some specified group of phenomena either asserted merely as a provisional conjecture to guide some investigation or accepted as highly probable in the light of established facts (Kothari & Garg, 2014). The hypotheses of the study were tested using the t-test. Each independent variable was regressed on the dependent variable using SPSS version 26. The researcher selected a level of significance of α=0.05 as a criterion for judging the null hypotheses. The significance level is the desired probability of rejecting the null hypothesis when it is true (Kothari & Garg, 2014). This means that the researcher was willing to take a 5% risk of falsely rejecting the null hypothesis. Where the p-value was less than 0.05 the researcher rejected the null hypothesis and where the p- value was greater than 0.05 the researcher failed to reject the null hypothesis.

3.11.2 Qualitative Data Analysis

3.11.2.1 Content Analysis

The study used content analysis to analyse qualitative data from interviews. Content analysis can be used for drawing systematic, reliable or binding and repeatable conclusions from texts and other kinds of communication (Drisko & Maschi, 2016).

The researcher established specific words present in texts, created categories and counted the number of times those categories were used in a specific text. In the study, it was feasible to deal with primary data directly through content analysis, which was processed both quantitatively and qualitatively. In addition, content analysis allowed assigning successive parts of qualitative material to categories for interpretation and made it possible to systematically focus on selected aspects of the researcher's material.

Data from observation was subjectively interpreted and was used to discuss quantitative results. Because the study used a sequential explanatory mixed methodology, information gathered through qualitative methods was used to explain the findings of quantitative approach.

3.12 Ethical Considerations

To ensure that the study was ethically conducted, permission to conduct research was sought from relevant authorities including; Moi University, Kampala Capital City Authority, Makerere University School of Social Sciences Research Ethics Committee, Uganda National Council for Science and Technology and the National Commission for Science, Technology &Innovation

In addition, the researcher sought the consent of respondents to participate in the study. For this purpose, consent forms attached to questionnaires were formulated as shown in (Appendix VI). The consent forms explained the purpose of the study and informed the participants that the survey was for academic purposes only and was authorized by Uganda National Council of Science and Technology. The forms also explained, the nature of questions, what is expected of them, the benefits and risks, the length of the study and were given the opportunity to ask questions. Consent forms were completed

and signed by consenting respondents. Therefore, participation in the survey was purely voluntary and left to the discretion of participants.

The researcher ensured confidentiality of the information given by different respondents. Confidentiality was achieved by the researcher pledging to keep the completed surveys secure long after the study was completed and by treating each respondent in isolation to guard against external meddling. This made respondents trust the researcher and enabled them to give accurate information.

Further, anonymity was assured to respondents. This was achieved by ensuring that they did not write their names on the questionnaire so as to guard their identity and in cases where respondents wrote names on the questionnaire, this was erased immediately it was identified.

3.13 Chapter Summary

This chapter has described the steps taken to conduct a study on climate variability adaptation strategies and livelihood of smallholder vegetable farmers in Kampala District, Uganda. The study was based on pragmatic research paradigm which believes that there are many different ways of interpreting the world and that no single point of view can ever give the entire picture as there may be multiple realities. The study adopted explanatory sequential design. The design is used in mixed research studies where qualitative data is used to refine and explain statistical results in the initial quantitative strand. It is used in studies that start with the collection and analysis of quantitative data first and then followed by the subsequent collection and analysis of qualitative data. In this study the researcher sought to explain climate variability adaptation strategies and livelihood of smallholder farmers. The study also examined

whether technological, farm production, government support and farm financial management adaptations had an effect on livelihood of smallholder farmers.

The study was carried out in Kampala district, Uganda. The district was considered suitable for this study due to its urban nature, exposure to climate variability and importance of agricultural systems. The study targeted all smallholder vegetable farmers, NAADS and KCCA officials in the five administrative divisions Kampala district. Proportionate stratified random sampling technique was used to select the sample of smallholder vegetable farmers. Selection of the sample was based on representativeness. The final number of respondents who participated in the study was 302 that is 292 smallholder vegetable farmers, 5 NAADS officials and 5 KCCA officials.

Questionnaires, interview schedule, observation guides were used for data collection. Further, validity of instruments was ascertained through expert opinions, discussions, suggestions from KCCA officials, operational definition of constructs in the study and subjective assessment of the presentation of the instruments. Reliability of the instruments was assessed using pilot study in Entebbe, municipality in Wakiso district. For the analysis of data, descriptive and inferential statistics were involved as well as content analysis. Ethical considerations involved in the study were also discussed.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents data analysis, interpretation and discussion of findings as per objectives of the study. The chapter analyses the response rate, preliminary tests, descriptive and inferential statistics and hypotheses testing.

4.2 Response Rate

A total of 292 questionnaires were issued, out of which 201 were filled and returned thus a response rate of 68.8% as shown in Table 4.1. The response rate was attributed to administration of the questionnaires by the researcher and prior notification of respondents before the date of data collection. In addition, further explanations were made during filling of questionnaires to clarify questions. The percentage of questionnaires not returned is 31%. The reason for this non-return rate was that some respondents insisted to fill the questionnaires themselves and in the process some were not returned. The returned questionnaires were deemed sufficient for analysis and reporting since according to Mugenda and Mugenda (2003), a response rate of 50% is adequate for data analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent.

Table 4.1: Response Rate

	Count	**Percentage**
Returned	201	68.83
Non-returned	91	31.17
Total	292	100

Source: Author's Compilation (2021)

4.3 Preliminary Analyses Tests

4.3.1 Data Screening

The rationale for screening of data is to protect the integrity of data analyses and inferential statistics tests (Tabachnick & Fidell, 2019). Output and analysis quality are dependent upon the quality of preliminary data screening (Hair *et al*., 2010). In view of the effect of missing data in analysis, questionnaires were thoroughly checked upon receipt to make sure that all questions were properly answered to prevent the problem of missing information right from the field in an effort to decrease their rate.

Further, data was screened according to guidelines provided by Tabachnick and Fidell (2019) which include; deleting cases or variables with missing values, estimating missing data, using a mixing data correlation matrix, treating missing data as data, repeating analyses with and without missing data. The researcher repeated analyses with and without missing data. According to Tabachnick and Fidell (2019), variables with missing values could be ignored or retained if missing values are fewer than 5%. In the study, missing values less than 5% were retained.

4.3.2 Data Coding

The returned questionnaires (201) were keyed into SPSS version 26 variable view page. Each item was coded and given a label based on its main variable initials and under the same latent construct.

4.3.3 Assessment of Outliers

Data screening also involved the treatment and assessment of outliers. Outliers are extreme scores or values of data sets that may significantly affect the analysis and the result of the study (Hair *et al*., 2010). The presence of outliers in a regression-based analysis data set can seriously mislead the estimates of regression coefficients and lead

to unreliable results (Verardi & Croux, 2008). As shown in Table 4.2 standardized variable values (z-scores) were used to detect the presence of univariate outliers.

Table 4.2: Assessment of Outliers using Standardized Values

Variable	**Statistics**	**Values**	**Std. error**	**Standardized values**
Livelihood	Skewness	-1.398	.472	-2.962
	Kurtosis	1.721	.641	2.685
Technological	Skewness	-1.401	.472	-2.987
	Kurtosis	1.206	.641	1.881
Government support	Skewness	-1.538	.472	-3.258
	Kurtosis	.705	.641	1.589
Farm production	Skewness	-1.083	.472	-2.294
	Kurtosis	1.436	.641	2.240
Financial management	Skewness	-1.021	.472	-2.163
	Kurtosis	1.311	.641	2.045

Source: *Author's Compilation (2021)*

According to Abu-Bader (2010) standardized values can be used with a general guideline that the absolute z values larger than 3 are considered to be outliers, some statisticians use a cutoff z value of 4 or greater for large samples and for small sample sizes a cutoff of 2.5 is used. The above results reveal that there were no outliers in the data set and thus no cases were removed since the standardized value for each variable was less than the absolute values. All the data were used in regression analysis.

4.4 Demographic Characteristics of Respondents

The study sought to determine the demographic characteristics of the respondents who participated in the study. Specifically the section focused on gender, marital status, age, household headship, income and occupation of respondents.

4.4.1 Gender of Respondents

The study sought to establish the gender of respondents. Study findings as shown in Figure 4.1 revealed that 72% of the respondents were female while 28% were male.

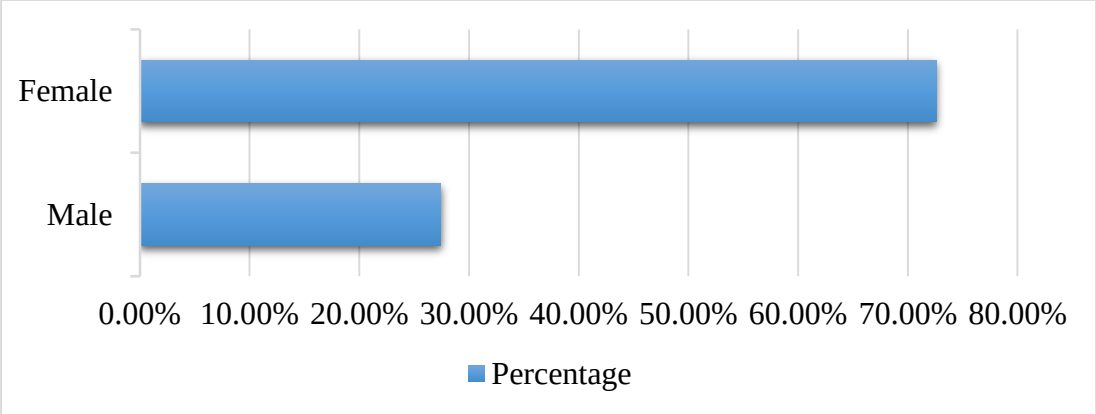

Figure 4.1 Gender of Respondents

Source: Author's Compilation (2021)

The findings above indicate that a majority of vegetable farmers (72%) were female. The finding can be associated with the gender division of labor in many traditional African societies where women are assigned to manage the home, do domestic chores and manage kitchen gardens. The results depict the phenomenon of feminization of crop production where certain crops like vegetables are regarded as crops grown by females. This finding is consistent with Odewumi *et al*. (2013) who observed that in Ibadan metropolis vegetable farming was mainly done by women in order to support their families nutritionally and economic wise. In addition the findings of this study are consistent with Wuyep *et al*. (2021) who found that in Jos Nigeria women constituted the majority of participants in urban vegetable farming with an aim of increasing food security and income levels for their families.

4.4.2 Marital Status of Respondents

The study also sought to establish the marital status of vegetable farmers. Study findings as shown in Table 4.3 revealed that 114(56.7%) of the respondents were married, 40(19.9%) widow/widower, 37(18.4%) single, 6(2.9%) separated while 4(1.9%) were divorced.

Table 4.3: Marital Status of Vegetable Farmers

	Frequency	Percent
Married	114	56.7
Widowed	40	19.9
Single	37	18.4
Separated	6	2.9
Divorced	4	1.9
Total	198	100

Source: Author's Compilation (2021)

From the findings a majority of respondents (56.7%) were married while the least were divorced. The high percentage of the married engaging in vegetable farming is associated to the collaborative relationships in vegetable farming with spouses and thus marriage is a very important institution in urban farming. The findings portray a positive attitude and response among married persons toward vegetable farming and thus engaging in it as a livelihood strategy was imperative for them. The finding of this study subscribes to Mugisha *et al*. (2017) who found that two thirds of the sample size who engaged in urban and peri-urban crop farming in central Uganda were married. Furthermore, this finding is in line with Ngegba *et al*. (2016) who stated that over half of the farmers in Koinadugu district, Northern Sierra Leon were married.

4.4.3 Age of Respondents

The study sought to establish the age of respondents. Study findings as shown in Figure 4.2 revealed that 47% of the respondents were above 41 years of age, 17% were aged

between 31-35 years, 14% between 26-30 years, 13% aged between 36- 40 years, while the least (9%) were between 18 -25 years.

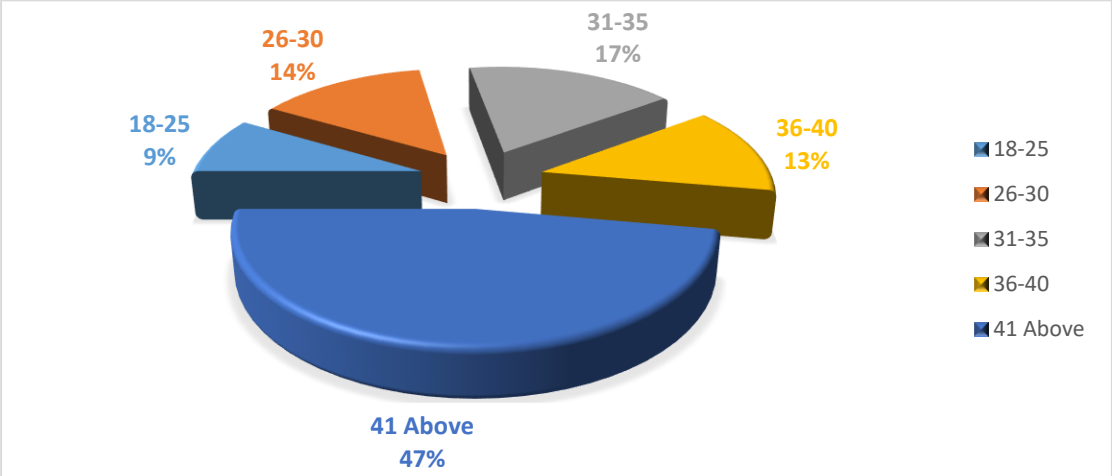

Figure 4.2: Age of Respondents

Source: Author's Compilation (2021)

The survey data as shown above indicates that majority of vegetable farmers (47%) were above 41 years of age. This means that they are mature enough to make adaptation decisions on their vegetable farms. In addition, they understand the benefits accruing from vegetable farming in urban areas and thus taking it up as an income generating venture. This percentage confirms the need for concerted efforts to support this age group of the population given their numbers and the potential to boost urban farming and food security. The results are consistent with Yamba *et al*. (2017) who found that most smallholder farmers in rural Ghana were above forty one years and thus were young and energetic to the extent that if they are resourced they could engage in alternative economic activities which play a critical role in the adaptation process. Furthermore, this finding is in line with Wuyep *et al*. (2021) who observed that most urban farmers in Jos the capital of Plateau State, Nigeria were in the 41-50 years age bracket and mostly conducted their farming activities on a part-time basis.

This finding is also supported by a key informant who claimed that age is an important determinant in urban farming adaptation and noted;

> *"Smallholder farmers who have advanced in age fall within the active age group in farming. Again, this age group is more likely than young ones to display increasing interest in vegetable farming, has got more experience, expertise, technology and access to urban and peri-urban resources like land"* (NAADS official, 2021).

4.4.4 Education Level of Respondents

The study sought to evaluate level of respondents' education. Study findings as shown in Figure 4.3 revealed that 45% of the respondents had secondary education level, 32% had primary school education, 12% had tertiary institution education, and 10% had attained university education while the least 1% had not attained any education level.

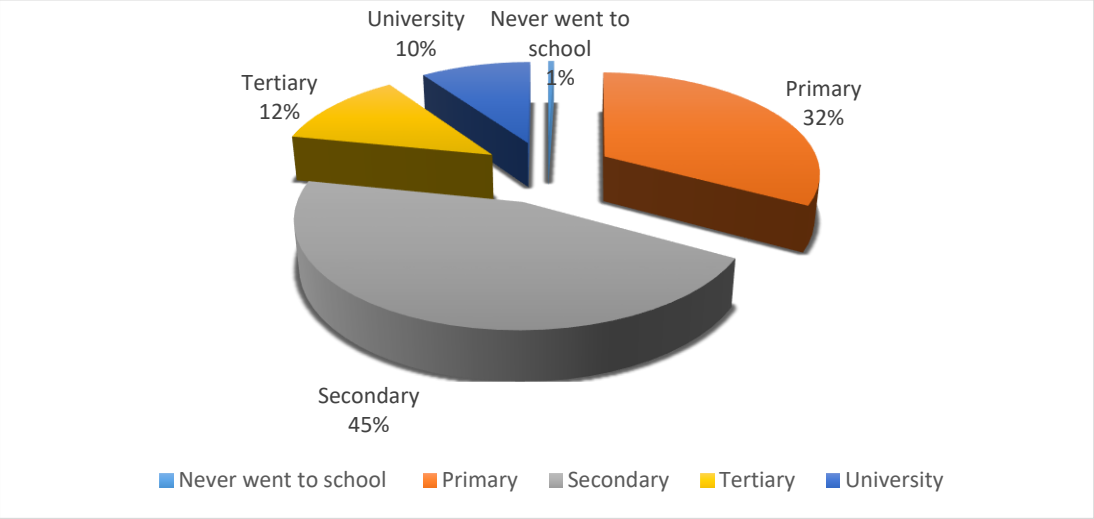

Figure 4.3: Level of Education of Respondents

Source: Author's Compilation (2021)

From the findings majority (45%) of vegetable farmers in Kampala district had acquired formal education while a very small percentage had not acquired any formal education. The high percentage of vegetable farmers with formal education is associated to the value attached to education and thus an important personal trait in climate variability adaptation. An educated population is more likely to perceive climate variability and

embrace adaptation strategies since she or he is enlightened and aware of the negative impacts compared to an uneducated population. The finding is supported by Odewumi *et al*. (2013) who noted that most farmers in Ibadan Metropolis had post-primary and post-secondary education hence likely to perceive effects of climate change and variation on urban agriculture. However, the finding contradicts the finding of Ngegba *et al*. (2016) and Kapoor (2011). Ngegba *et al*. (2016) revealed that Quaranic education was the highest level of education attained by farmers in the district and thus less likely to adopt new innovations resulting in reduced productivity and hence low farm returns. While, Kapoor (2011) found that most farmers in Shringverpur had no formal education and were less likely to embrace natural resource conservation techniques, less likely to appreciate the role of information channels like television and radio in dissemination of environmental awareness needed in climate change adaptation.

4.4.5 Household Head

The study also sought to establish the heads of households. Study findings as shown in Table 4.4 revealed that out of 201 vegetable farmers only 94 (46.8%) were household heads while 107 (53.2%) were not household heads.

Table 4.4: Household Head

	Frequency	**Percent**
Household Heads	94	46.8
Non-household heads	107	53.2
Total	**201**	**100.0**

Source: Author's Compilation (2021)

In the current study household heads were wives if they were widows, husbands or single decision makers in separated, divorced and single parent households. Non-household heads were wives or those individuals who did not make decisions in

separated, divorced and single parent households. From the findings, a majority of vegetable farmers were not household heads this is associated with the fact that most farmers were women and married therefore were not household heads as dictated by African societal norms. In consequence, this meant that most respondents participated in vegetable farming but were not spearheading coordination, control, management and adaptation decision making thus less likely to be in control of climate variability adaptation decision making amidst extreme climatic conditions. The non-household heads were therefore at the receiving end doing more of implementation work on the orders of household heads.

The finding is supported by the 2014 census which noted that a higher percentage of male headed households (81%) were involved in agriculture in Uganda compared to female headed households (75%) (Uganda Bureau of Statistics, 2016). In addition, the result correlates with Victor *et al*. (2018) and Jongwe (2014). Victor *et al*. (2018) found that the small number of female headed households participating in urban agriculture in comparison with the number of male headed households might be attributed to the presence of few female headed households. While Jongwe (2014) noted that urban agriculture participation in Zimbabwe's Gweru city was dominated by male-headed households and that households headed by formally employed heads stand a better chance of getting urban agriculture plots compared to those headed by unemployed household heads.

4.4.6 Income of Respondents

The study also sought to find out the income of smallholder vegetable farmers. The findings as shown in table 4.5 revealed that 126(62.6%) earned between 10000-100000 Uganda shillings, 30(15.0%) earned between 110000- 200000 Uganda shillings, while

18(9.0%) earned 210000-300000, 10(4.9%) earned between 310000-400000, 9(4.4%) earned 410000-500000 and the least 8(4.0%) earned 510000 and above.

Table 4.5: Income of Respondents

Uganda Shillings	Frequency	Percent
10,000-100,000 (339-3,397 Ksh)	126	62.6
110,000- 200,000 (3,736-6,794 Ksh)	30	15.0
210,000-300,000 (7,133-10,191 Ksh)	18	9.0
310,000-400000 (10,530-13,588 Ksh.)	10	4.9
410000-500000 (13,927-16,985 Ksh.)	9	4.4
Above 510,000 (17,324 Ksh.)	8	4.0
Total	201	100.00

Source: Author's Compilation (2021)

From the findings a majority of vegetable farmers earned between 10,000-100,000 Uganda Shillings and thus in the low income bracket. The finding on income depicts that a majority of vegetable farmers are living below the national poverty line of between 0.88US dollars and 1.04 US dollars per day. The low income could be a motivator for the low income earners to engage in urban vegetable farming as a source of food supply in order to cut on the cost of family maintenance and as a way to supplement their domestic income. Due to low income of the smallholder vegetable farmers, they may be prone to climatic and non-climatic shocks and therefore requiring quality adaptation strategies in order to maintain a descent livelihood. The finding is supported by Development Initiatives progress report (2020) which noted that 54% of the Ugandan population lives below the national poverty line and that the proportion of

people who live above the poverty line but remained vulnerable to falling below it due to shocks has increased.

4.4.7 Occupation of Respondents

The study sought to establish the occupation of respondents in the study as shown in Table 4.6. The results revealed that 145(72.1%) were housewives, 10 (5.5%) were teachers, 12(6.5%) were doing business, 5(2.5%) were students, and 5(2.5%) were tailors. A small percentage of respondents (11.0%) were; bankers, accountants, hawkers, stylists, cleaners, journalists, mansions, caterers, matron, chairperson, social worker, food vendors, shoe vendors, secretaries, shop attendants and poultry farmers.

Table 4.6: Occupation of the Respondents

	Frequency	Percent
Banker	2	1.0
Teacher	10	5.5
Accountant	2	1.0
Business people	12	6.5
House wife	145	72.1
Food vendor	5	1.5
Hawker	1	.5
Salon/Hair stylist	1	.5
Cleaner	1	.5
Journalist	1	.5
Mansion	1	.5
Catering	1	.5
Matron	1	.5
Chairman	1	.5
Student	5	2.5
Tailor/Tailoring	5	2.5
Secretarial	2	1.0
Shop attendant	2	1.0
Social worker	1	.5
Shoe vendor	1	.5
Poultry farming	1	.5
Total	201	100.0

Source: Author's Compilation (2021)

The survey data as indicated in the table above shows that, majority of vegetable farmers were housewives. Since most housewives have free time to engage in urban farming they do it due to the need to maintain family food supply, supplement family diet and generate family income and thus participating. From the findings, it is also clear that persons of various occupations practiced vegetable farming and thus it is not only a reserve of the unemployed but also the employed and salaried persons. The finding is supported by Joshi *et al*., 2003 (as cited in Naznin *et al*., 2015) who found that in rural areas of Bangladesh off-farm wage labor and non-farm self-employment such as teaching, small business, brick lying and working on a construction site, fish farming and livestock are all sources of income.

4.5 Smallholder Farm Characteristics

In articulating the set objectives, farm characteristics provided significant information that helped in answering the main objective of the study. This section focuses on the smallholder vegetable farming characteristics as shown in (Table 4.7).

Table 4.7: Smallholder Farming Characteristics

Characteristic	Category	Frequency	Percent
Type of urban farming practiced	Vegetable	147	73.1
	Both vegetable and livestock	54	26.9
	Total	201	100.0
Vegetables grown in 2020	Fruit Vegetables	53	26.4
	Leaf Vegetables	147	73.1
	Root vegetables	1	.5
	Total	201	100.0
How long do vegetables take to mature?	Non-response	1	.5
	8 months and above	5	2.5
	1-3Months	186	92.5
	4-7Months	9	4.5
	Total	201	100.0
Where do you grow vegetables?	Non-response	1	.5
	Homestead (on-plot)	169	84.1
	Land away from the residence (off-plot)	31	15.4
	Total	201	100.0
How long have you grown Vegetables?	1-5years	130	64.7
	6-10years	40	19.9
	11-15years	11	5.5
	16-20	10	5.0
	20years and above	10	5.0
	Total	201	100.0

Source: Author's Compilation (2021)

4.5.1 Type of Urban Farming Practiced

The study sought to establish the types of urban farming practiced by vegetable farmers. Study findings as shown in Table 4.7 revealed that 147(73.1%) of the respondents practiced vegetable farming only while 54 (26.9%) engaged in both vegetable and livestock farming. Plate 4.1 and plate 4.2 show the two types of farming practiced by the vegetable farmers.

Plate 4.1: Showing Sukuma Wiki garden in Makindye Division

Source: Author (2021)

Plate 4.2: Showing piggery farming next to a Vegetable farm in Kawempe division

Source: Author (2021)

The high preference for vegetable farming only over integrated farming is associated to farmers' ability to cultivate vegetables on a small area that can be taken care of , the high market value of vegetables in urban areas and to shorter time vegetables take to

cultivate. The finding is supported by Tilahun and Adelegn (2019) who noted that in Debre Berhan town central Ethiopia, vegetable cultivation was the most common practice and involved planting of carrots, cabbage, potatoes, lettuce, beet root and spinach for self-consumption and marketing using simple cultivation techniques like irrigation during the summer season.

The finding of this study contradicts Namara (2011) and Victor *et al*. (2018). Namara (2011) reported that urban farming which is one of the prevalent land use practices in Kawempe division, Kampala district was dominated by animal farming followed by crop farming and poultry. The finding also contradicts Victor *et al*. (2018) who found that in Kinondoni Municipality Tanzania, out of the three types of integration practiced (crop-livestock, livestock-fishing and crop, fishing and livestock) most farmers concentrated on crop-livestock and only a few integrated livestock- fishing or crop, livestock and fishing. The study further revealed that integrated urban agriculture is a highly prioritized livelihood strategy among integrated farmers followed by business activities.

4.5.2 Type of Vegetables Grown

The study sought to establish the types of vegetables grown by respondents as shown in Table 4.8. The results revealed that 147(73.1%) of respondents planted leafy vegetables, 53(26.4%) planted fruit vegetables while 1(0.5%) planted root vegetables.

Table 4.8: Types of Vegetables Grown in Kampala District

	Frequency	Percent
Leafy Vegetables	147	73.1
Fruit Vegetables	53	26.4
Root Vegetables	1	0.5
Total	201	100.0

Source: Author's Compilation (2021)

From the findings majority of respondents planted leafy vegetables while the least planted root vegetables meaning that leafy vegetables were the most preferred type of vegetables. The high number of farmers that engaged in leafy vegetables could have been motivated by the health and economic benefits associated with leafy vegetables and the short period that they take to mature. In addition, observation data revealed that the most preferred leafy vegetables were kales, spinach, solanum aethiopicum (*Nakati*), solanum nigrun (*ensugga*), gynandropsis gynandra (*ejjobyo*) and amaranthus dubius (*Doodo*) which were planted in compound gardens, tins and sack gardens at the back and front yards. Implying that, the choice of the vegetables was because of the small size of space required to manage them. This finding is consistent with Namara (2011) who observed that in Kawempe division leafy vegetables were the most preferred because they required less land and thus could be done even in the compound and were more profitable in urban areas.

4.5.3 Duration Crops Took to Mature

The study sought to evaluate the period vegetables grown took to mature. Study findings as shown in Table 4.7 revealed that 186(92.5%) grew vegetables that took 1-3months, 9(4.5%) grew vegetables that matured between 4-7months while 5(2.5%) grew vegetables that matured from 8months and above. The high preference for planting vegetables that take three months to mature is associated with the desire to enjoy the benefits of planting vegetables such as gaining income and family dietary needs within a short time span. In addition, the prevalence of climate variability compels farmers to plant quick maturing crops in order to minimize crop loss caused by climate change and variability.

In support, a NAADS official in an interview said;

> *"Scientifically, crop growing period cannot be the same for all vegetables….Some crops will take longer than others depending on the environmental conditions prevailing during growth such as temperature and rainfall. Spinach and sukuma wiki need approximately six weeks to eight weeks, while tomatoes take between 50days to 90 days to be harvested. Therefore it is upon the individual farmer to choose the crops they prefer depending on their socio-economic, political and environmental motives"* (NAADS official, 2021).

4.5.4 Location of Vegetable Gardens

The study sought to establish the location of vegetable gardens. Study findings as shown in Table 4.9 revealed 169(84.1%) of respondents planted vegetables at the homesteads (on-plot), while the least 32(15.9%) planted on land away from their homesteads (off-plot)

Table 4.9: Location of Vegetable Gardens

	Frequency	**Percent**
On-Plot	169	84.1
Off-Plot	32	15.9
Total	201	100.0

Source: Author's Compilation (2021)

The findings above reveal that majority of farmers planted vegetables on-plot meaning that farmers did not travel to access vegetable gardens thus close care and monitoring of vegetable gardens in order to reduce vulnerability of vegetable gardens to extreme weather conditions. The findings of this study subscribes to Azuba, 2002 (as cited in Sabiiti *et al*., 2014) who reported that most farming households in Kampala city maintained backyard gardens on less than 0.4 hectares while off-plot farming was mainly practiced by institutions and households in peri-urban areas on two or more hectares. Furthermore, the findings of this study are supported by Flynn (2001) who reported that most urban farmers in Mwanza town Tanzania maintained "kitchen

gardens" or gardens adjacent to their dwellings while a few others had gardens located at a distance from their dwelling. Similar results were reported by Masvaure (2015) who observed that urban agriculture in Glen Norah took two forms; on-plot cultivation and off-plot urban cultivation where on-plot cultivation was mainly conducted by households who own houses within their residential demarcated areas and the main types of crops produced were vegetables while off-plot cultivation was mainly conducted on land which did not belong to the farmers.

4.5.5 Farming Experience

The study also sought to find out the number years farmers had practiced vegetable farming as shown in Table 4.7. The results revealed 130(64.7%) of respondents had 1-5 years' experience, 40(19.9%) had 6-10 years' experience, 11(5.5%) had 11-15 years' experience, 10(5.0%) had 16-20 years' experience, while 10(5.0%) had experience of 20 years and above. The high percentage of farmers with farming experience between 1-5 years means that farmers were quite new to vegetable farming. This could be associated with intensified campaigns and urban policies in favor of vegetable farming in the last five years and deepening economic hardships which motivates farmers to augment their livelihood through vegetable farming. In terms of implementation of climate variability adaptation, this period is long enough to appreciate and give good account of climate variability, which would help them to employ appropriate adaptation strategies to mitigate the effects of climate variability and sustain farmers livelihood. The finding of this study contradicts Odewumi *et al*. (2013) who stated that a large percentage of farmers in Ibadan metropolis in Nigeria had farming experience that ranged between 6 - 10 years and that length of farming directly influenced farmer's perception of the effect of climate variations on urban agriculture.

4.6 Climate Variability Adaptation Strategies

4.6.1 Awareness of Climate Variability Indicators

In order to determine the climate variability adaptation strategies, the study sought to establish whether farmers were aware of climatic variations. The findings as shown in Table 4.10 revealed that 173(86.1%) of respondents were aware of climate variability while 28(13.9%) were not aware of climate variability.

Table 4.10: Awareness of Climate Variability

	Frequency	Percent
Yes	173	86.1
No	28	13.9
Total	201	100.0

Source: Author's Compilation (2021)

From the findings, it is clear that most farmers were aware of climatic variations and that climate variability was happening in their locality. This therefore implies that given the requisite support and resources the farmers would implement climate variability adaptation strategies so that climate variability does not affect their vegetable farming. In addition, knowledge of climate variability would help farmers mobilise resources needed in the adaptation process and this would help build and strengthen farmers' capacity to develop appropriate adaptation strategies necessary to confront present and future extreme weather events. This finding is supported by a key informant who noted;

> *"Many urban farmers are aware of seasonal weather changes taking place in the district. The variations are nowadays a reality, have become more rampant and therefore easily noticed by most farmers"* (NAADS official, 2021).

The finding of this study concurs with Mubiru *et al*. (2018) who revealed that majority of farmers in Hoima and Rakai districts Uganda reported changes in weather patterns. In addition, the finding is supported by Odewumi *et al*. (2013) who revealed that most

farmers in Ibadan Metropolis held the opinion that the climate was changing and variability in climate conditions had become more pronounced. However, the finding of this study is negated by Mutekwa (2009) who found that most farmers in Zimbabwe professed ignorance about climate change and its potential consequences, whilst a minority had observed some kind of change in recent years.

A breakdown of respondents' perception on climatic variability as shown in Table 4.11 revealed that (M=4.24) perceived climate variability in terms of increase in rainfall, (M=4.21) perceived climate variability in terms of increase in temperature, while (M=3.78) perceived climate variability in terms of increase in wind flow.

Table 4.11: Perception on Climate Variability Indicators

	Min	**Max**	**Mean**	**Std. Err**	**Std. Dev**
Increase in rainfall in 2020	1.00	5.00	4.24	0.06	0.85
Increase in temperature in 2020	1.00	5.00	4.21	0.05	0.78
Increase in wind flow in 2020	1.00	5.00	3.78	0.08	1.13
Overall Mean			3.92	0.05	0.71

Source: Author's Compilation (2021)

From the findings, majority of farmers perceived climate variability in terms of an increase in rainfall while the least perceived it in terms of an increase in wind flow. This therefore implies that amidst increases in rainfall, farmers would employ adaptation strategies needed to avert crop damage and loss emanating from increased rainfall. In addition, knowledge of increased rainfall would help farmers and organizations initiate water conservation campaigns and efforts to ensure that rain water runoff is tapped and stored for use during dry seasons. The findings of this study are

supported by UNMA (2020) seasonal climate outlooks for September 2019 and December 2020 which stated that the central region would experience occasional outbreaks of heavy showers, thunderstorms, flash floods, above normal rainfall.

The findings of this study are negated by Munthali *et al*. (2016) that in Bolero community of northern Malawi, majority of farmers believed that rainfall in the community had decreased and temperatures had increased. In addition, a study by Mutekwa (2009) reported that farmers noted that below normal rainfall years were becoming more frequent thus exacerbating food insecurity throughout the area and also pointed out that rainfall patterns had become highly unpredictable in the last few years to the extent that they could not predict the time of onset of seasonal rainfall.

4.6.2 Application of Climate Variability Adaptation Strategies

The researcher also assessed whether respondents applied climate variability adaptation strategies in 2020. As presented in Table 4.12, 168(83.6%) of respondents applied adaptation strategies while 33 (16.4%) did not apply adaptation strategies.

Table 4.12: Application of Climate Variability Adaptation Strategies

	Frequency	Percent
Yes	168	83.6
No	33	16.4
Total	201	100.0

Source: Author's Compilation (2021)

The large number of respondents who applied adaptation strategies on their vegetable gardens can be closely linked to the importance smallholder farmers attached to adaptation strategies as means to minimize climate variability impact and farmers awareness of the risks changes in climatic variations pose to their livelihood. This therefore implies that adaptation strategies were employed by vegetable farmers to enhance their adaptive capacity so as to take advantage of emerging opportunities and

cope with extreme events. An interview with a KCCA official revealed that adaptation to harsh climatic conditions in Uganda was not a new phenomenon among urban farmers as he noted;

> *"Smallholder farmers have always used adaptation strategies to safeguard their crops during flooding, droughts, hailstones and storms. In line with the adverse effects of climate variability, farmers are willing to respond to climate anomalies in order to achieve their livelihood goals. And the adaptation practices and technologies offer proven paybacks to farmers like increase in income, food access and nutrition"* (KCCA official, 2021).

The study finding is consistent with Josh *et al*. (2017) who stated that most farm households in the Mountain District of Nepal applied adaptation strategies to improve society's ability to cope with the impact of changes. In addition, the finding is supported by Odewumi *et al*. (2013) who found that urban farmers in Ibadan Metropolis devised coping strategies like irrigation, application of fertilizers, and practice of dry mulching and application of chemicals to minimize impacts of change in the climatic conditions. The finding is consistent with Jummai (2013) who stated that most farmers in the semi-Arid Nguru location used adaptation strategies to reduce negative consequences of variability in climate conditions.

4.6.1.1 Technological Developments Adaptation Strategies

The study sought to establish technological development adaptation strategies employed by smallholder vegetable farmers. The results are presented in Table 4.13.

Table 4.13: Technological Adaptation Strategies

Variables	Min	Max	Mean	Std. Error	Std. Deviation
Weather forecast and climate information and used it in planning	1.00	5.00	4.00	0.07	1.06
Water harvesting for irrigation	1.00	5.00	3.85	0.08	1.07
Changing soil conservation technologies	1.00	5.00	3.78	0.08	1.13
Water pans for irrigation	1.00	5.00	3.76	0.09	1.25
Planting a variety of vegetables	1.00	5.00	3.69	0.09	1.27
Overall mean			3.82	0.05	0.59

Source: Author's Compilation (2021)

The finding indicates that majority of farmers (mean 4.00) used weather forecast and climate information to cope with changes in climate conditions. The high reliance on weather forecast and climate information is associated to the accuracy and appropriateness of climate information that would help in coming up with appropriate adaptation strategies. Information on seasonal and daily forecast is necessary for rain-fed vegetable farming which constitute the main source of livelihood for poor households. The finding is supported by interview data which revealed that Meteorological department provided climate weather forecast and climate information to farmers on a regular basis to prepare themselves for any eventualities. This was opined by a NAADS official who stated;

> *"Nowadays the meteorological department provides customer-focused and timely information to all users. In particular, it sends simplified advisory messages to farmers in various local languages to equip them with knowledge about weather patterns during planting season as well as anticipated situations for them to plan better and avert loss of crops and livelihood"* (NAADS officer, 2021).

The finding is also supported by various scholars for instance, Gebru and Mworozi (2015) reported that timely delivery of localized climate information reduced crop loss

and damage by 67% per household per year and made communities more resilient to the impacts of climate variability and change. In addition, the finding of the study concurs with Valdivia *et al.* (2010) who revealed that in Andean Ecosystems weather forecast assisted farmers to make management decisions develop and apply operational tools to manage weather related uncertainties in rapidly changing environments.

The study sought to find out sources of weather forecast and climate information and as shown in table 4.14, it was established that farmers accessed weather and climate information via television (M=3.77, SE=0.08), radio (M=3.77, SE=0.08), mobile phone (M=3.75, SE=0.09), neighbors (M=3.70, SE=0.09) and Newspapers (M=3.52, SE=0.09).

Table 4.14: Sources of Weather Forecast and Climate Information

Source of Information	Min	Max	Mean	Std. Error	Std. Deviation
Television	1.00	5.00	3.77	0.08	1.10
Radio	1.00	5.00	3.77	0.08	1.10
Mobile phone	1.00	5.00	3.75	0.09	1.24
Neighbours	1.00	5.00	3.70	0.09	1.26
Newspapers	1.00	5.00	3.52	0.09	1.33
Overall mean			3.70	0.05	0.49

Source: Author's Compilation (2021)

From the findings, most respondents accessed weather forecast and climate information via television and radio, a considerable proportion accessed it via mobile phone and neighbors and the least number of respondents accessed weather information via Newspapers. The results depict availability of many sources of weather forecast and climate information which ensure that every person gets the climate information. This information would help to know when to plant, what to plant, when to harvest the crops

and the price at which to sell what is harvested thus increase vegetable production and thus improving livelihood of the vegetable farmers. In addition, various sources of weather forecast and climate information would help the farmers better manage climate risks and take advantage of favorable climate conditions.

An interview with a KCCA official revealed existence of various climate information sources for Kampala district residents as she noted;

> *"Many television channels and radio stations in Uganda provide weather forecast information. In fact, prominent TV channels such as UBC, NTV, Bukedde, NBS and radio stations broadcast climate information during the News hour*" (KCCA officer, 2021).

The finding of this study is consistent with Kapoor (2011) who found that in Shringverpur village of Soraon Tehsil Allahabad district of Uttar Pradesh, India, television, radio and Newspapers were information tools used by farmers. Kapoor (2011) attributed the high preference for radio to ease of use by both literate and illiterate persons and superiority of television to ease of learning through the visual mass media. Kapoor added that the mass media were playing a crucial part in raising environmental awareness and information about new agriculture technologies among rural people.

The finding of this study is also in line with Musa and Sulaiman (2017) who indicated that in Northern Nigeria climate change information was largely disseminated through other farmers like friends, relatives and neighbors, use of the radio, cooperative group members, open market and government extension agents. It can be argued that availability of various sources of weather forecast and climate information helps to reduce crop loss and damage which results in increase in vegetable productivity and resilience of communities.

Results as shown in Table 4.13 further revealed that smallholders farmers used water harvesting (M=3.85, SE=0.08) as a technological adaptation strategy to cope with adverse seasonal variations in climatic conditions. This involved use of both traditional and modern water harvesting techniques such as plastic water tanks (Plate 4.3) to collect rain water from rooftops with the help of gutters. The harvested water would help to irrigate vegetable crops during the dry season and meet other domestic water requirements thus saving on water bills and at the same time improve on vegetable production and consequently help enhance their livelihood. Farming in Uganda is mainly reliant on the climate irrigation essentially helps farmers to guarantee crop production throughout the year.

Plate 4.3: Showing rain water harvesting using a plastic tank and gutters, in Makindye division

Source: Author (2021)

An interview with a NAADS official revealed that various techniques were used to apply harvested water on crops and noted;

> *".....some farmers relied on containers such as buckets and motorized water pumps to collect water from the water storage facilities and applied on the crops using rain gauge sprinklers and drip irrigation pipes during the dry season"* (NAADS official, 2021).

The finding concurs with Kohli *et al*. (2016) who stated that smallholder farmers in the plains of South Bihar used traditional water harvesting technologies to conserve and increase availability of water in areas that had inadequate water resources. In addition, the findings are supported by Smit and Skinner (2002) who indicated that farmers in Ontario employed farm level technologies to harvest rain water so as to address the risks associated with changing climatic conditions. Furthermore, the findings of this study are supported by Osewe *et al*. (2020) who revealed that farmers in Kilolo and Mbarali districts in Southern Tanzania relied greatly on irrigation to cope with climate change and variability. Osewe *et al*. added that the decision to adopt irrigation practice was determined by whether farmers had experienced drought, been to a water user group, owned assets, received extension services, as well as being a member of farmer organizations.

The finding indicate that farmers (mean 3.78) changed soil conservation techniques to cope with to climate variability and its effects. This was involved altering traditional and innovative soil conservation practices in order to maintain soil productivity and thus improve livelihood. This was aimed at stabilizing the soil throughout the planting season thus increase productivity. This finding is supported by a key informant who revealed;

> *"In my view farmers kept on changing soil conservation technologies to address the problem of poor soils which is partly attributed to climate variability related disasters such as flooding, heavy winds and*

> *drought that leave behind infertile and less productive soils"* (KCCA official, 2021).

The finding of this study concurs with earlier studies assessing soil conservation technologies among smallholder farmers. In particular this finding is supported by Wawire *et al*. (2021) who found that farmers in Mount Kenya East region applied fertilizers and manure to conserve soil and boost soil fertility. In addition, Mubiru *et al*. (2018) found that farmers in Rakai and Hoima districts used soil moisture conservation and soil fertility enhancement innovations as responses to climate related risks.

Further, the study sought to find out whether farmers used water pans as a technological adaptation strategy. It was established that use of water pans was the fourth preferred technological adaptation strategy (M=3.76, SE=0.09). Here, farmers collected run off ground water in water pans and later used it to irrigate vegetable gardens thus building resilience to climate change and variability. This was aimed at ensuring continuous vegetable production over the drought period thus adequate supply of vegetables. The finding of this is study is supported by Lutta *et al*. (2020) who stated that farmers in the semi-arid rangelands of south Eastern Kenya used water pans to minimize agricultural risks and enhance productivity. Lutta *et al*. (2020) attributed the successful adoption and management of water pans to farmers' access to extension services and training, land tenure and membership to community groups.

In addition, the survey data found that farmers (mean=3.69, SE=0.09) planted a variety of vegetables in 2020 to cope with the negative impact of climate variability. This was achieved by farmers planting a variety of crops such as hybrid vegetables like cabbages, broccoli, spinach, Amaranthus Dubius, (*dodo*), African spider flower, eggplants, pepper and okra among others as shown in plate 4.4 so that in case some

failed due to adverse weather conditions, some would survive and support the family in terms nutrition and financially.

Plate 4.4: Showing Different types of Vegetables Planted in a Backyard Garden in Rubaga Division

Source: Author (2021)

With such a huge variety of vegetables with different climatic resistance levels, in case of adverse weather conditions the chances of some surviving was high thus a reduction in total loss as compared to if only one type of vegetable was planted. In addition, planting a variety of vegetables meant that chances of vegetables being susceptible to the same pests and diseases was low thus a reduction in destruction of the entire farm harvest and minimal use pesticides. The finding concurs with Kohli *et al*., (2016) who reported that farmers in India planted a variety of crops as a climate smart technology as crop varieties were least dependent on external inputs, had a lower incidence of pests, diseases and were capable of completing their life cycle. In support, Diallo *et al*. (2020) noted that farmers in southern Mali planted a variety of crops which helped in reducing vulnerability to climate change and variability and thus an important ingredient for increasing agricultural productivity and a reduction of poverty. It emerges from the findings that farmers applied several technological adaptation strategies which included; weather forecast and climate information, changing soil conservation, using

water pans and planting a variety of vegetables. Therefore, farmers in the study area adopted farm level strategies that worked best for them as precautionary measures to cushion against climate variability and its adverse effects.

4.6.1.2 Government Agricultural Support Programs

The study also sought to find out whether respondents received support from government towards vegetable farming. The study findings are shown in Table 4.15.

Table 4.15: Support toward Vegetable Farming in 2020

	Frequency	Percent
Yes	16	8.0
No	185	92.0
Total	201	100.0

Source: Author's Compilation (2021)

The large number of farmers who did not get government support toward vegetable farming can be closely linked to limited government commitment and politicization of government programs where some farmers wrongly perceive that programs are intended to benefit members of a certain political party leading to non-participation in such programs. The finding means that farmers implemented adaptation strategies mainly through individual initiatives. This therefore implies that farmers chances of preparing for and responding to the troublesome effects of climate variability were low as farmers did not benefit from cost-effective alternatives. The finding is supported by Hepelwa *et al*., 2013 study (as cited in Lameck, 2016) who stated that most poor households in Tanzania did not access government support and therefore the intended objective to increase productivity among poor smallholder farmers through the National Agricultural Input Voucher Scheme (NAIVS) was not reached. Hepelwa *et al*. (2013) as (cited in Lameck, 2016) attributed the minimal access to government agricultural

support to high market prices of agricultural inputs. This finding is supported by the National Planning Authority (2013) which states that despite the adoption of Plan for Modernization of Agriculture (PMA) in 2002 and the creation of NAADS programme in 2001 to improve livelihoods, smallholder farmers in Uganda received a disproportionately inadequate, inconsistent developmental resources and institutional support.

The study made a follow-up from respondents who received government support. The findings as shown in Table 4.16 revealed that (25.0%) of respondents received agricultural training, (31.3%) received extension services, (12.5%) subsidized credit, (18.8%) agricultural inputs, while (12.5%) received market support.

Table 4.16: Forms of Government Support

Form of Government Support	Frequency	Percent
Agricultural training	4	25.0
Agricultural extension services	5	31.3
subsidized credit	2	12.5
Agricultural inputs	3	18.8
Market support	2	12.5
Total	16	100.0

Source: Author's Compilation (2021)

From the findings, it is clear that agricultural training was the second accessed form of government support. Here, farmers were trained in practical skills, theoretical knowledge and agriculture technologies needed to run sustainable vegetable farming in a highly changing climate. This was aimed at making farmers understand the dynamics of the current and future climate variability and their impact on vegetable farming thus enhancing farmers' capacity to respond in good time. In support, a NAADS official noted during an interview that;

> *"At NAADS we continuously train farmers from within and beyond the district in skills and knowledge necessary for adaptation to climate change. For instance, farmers are trained every Wednesday and Saturday from 9am-5pm at Kyanja agricultural resource centre. Secondly, every year the vision group in collaboration with KCCA organizes a 'harvest Money Expo' which brings together farmers and practitioners in the agriculture sector to share knowledge and build farmers capacities. Therefore, offering agricultural training is part and parcel of what we do in the spirit of improving the living standards of people".* (NAADS officer, 2021)

Results as shown in Table 4.16 further revealed that most farmers (31.3%) accessed extension services as a form of government support. Here, district extension officers provided extension services in form of adaptation information, agriculture advise, technical support, advice and supply of inputs. This was aimed at building farmers capacity and increase production efficiency during climate variability. The finding of this study is supported by the Ministry of Finance, Planning and Economic Development (2019) which reported that the Ministry of Agriculture, Animal Industry and Fisheries reformed the extension services in FY2014/15 and introduced the Single Spine Agriculture Extension System to address challenges of extension among farmers. In addition, the finding is supported by Nuamah *et al*. (2019) who reported that farmers in Ghana relied on government extension services to respond to climate change since they had limited capacities to adapt to the changes on their own. Nuamah *et al*. added that extension services were provided to farmers in form of technical support and advice, supply of inputs and liaising with existing local institutions. Furthermore, the finding of this study concurs with DiFalco *et al*. (2011) who revealed that farmers in the Nile Basin of Ethiopia accessed government extension services which formed a core driver in adaptation efforts. The finding is negated by Defang and Amungwa (2017) that in Muyuka, Konye and Tombel sub-divisions in Meme, Fako and Kupe-Manenguba, Cameroon, extension services were accessed through farmer to farmer extension, personal experiences and not through the government.

The idea behind provision of different types of extension services is to help farmers address their adaptation challenges and adapt well to present and future climate variability through knowledge sharing. Therefore, it can be argued that extension services enhance farmers understanding of climate variability, its impacts on vegetable farming and thus ensures sustainable livelihood of during harsh climatic seasons.

The study findings also revealed that respondents (12.5%) accessed government subsidized credit as a form government support. This therefore implies that subsidized credit would enable farmers implement climate variability adaptation strategies so that climate variations do not affect their vegetable farming. In addition, subsidized credit would help farmers reduce agricultural expenditure and strengthen farmers' financial power needed to build resilience against climate variability shocks. An interview with a KCCA official revealed that some farmers accessed subsidized credit and noted;

> *"Some farmers were able to access government credit through government aided schemes and microfinance institutions especially those who had collateral and also those who belonged to farmers' groups. The advantage with farmers' groups is that they provide credit with less stringent terms and conditions"* (KCCA official, 2021).

In support of the findings, Ssonko and Nakayaga (2014) reported that some farmers in Mukono district Uganda, accessed government subsidized credit to improve returns on investment during times of limited cash flows. Ssonko and Nakayaga added that distance to credit facilities, easing application procedures, farm size, land tenure system, and being a member of farmer associations positively influenced the probability of a farmer demanding for credit.

Further, it was established from the study that (18.8%) of respondents received agricultural inputs as a form of government support. Here, farmers accessed fertilizers, high quality seeds, crop protection chemicals and seedlings which they used in

vegetable farming. This was aimed at maximizing crop production, productivity and profitability which boost household resilience to climatic variability. In addition, provision of agricultural in puts was aimed at scaling up and unlocking agriculture production among smallholder farmers. In support, observation findings revealed that inputs such as seedling of various crop varieties were sold to farmers at Kyanja resource center at subsidized prices. The center is managed by Kampala Capital City Authority and is set on 31 acres of land. It's objectives include; to demonstrate affordable urban farming technologies, offer hands-on training, produce high quality seeds for farmers (vegetable seedling, piglets, chicks and fish fingerlings), provide pig breeding services, carry out research and development for city farmers, and provide a bulking center to link farmers to lucrative markets (KCCA, 2016).

In addition, the survey data found that farmers (12.5%) received market support as a form of government support intended to reduce vulnerability of vegetable farming. Here, farmers received market information and market linkages which they used in planning and making of planting decisions (when to plant? what to plant?) in line with urban consumer demands. Furthermore, market linkages aim at ensuring that farmers negotiate from a position of greater strength which enables them to improve household income and livelihood. The study finding is supported by Renko *et al*. (2002) who reported that farmers in Croatia accessed government market support and this helped to improve agrarian structures, competiveness of local producers and identification, introduction and application of modern technologies. Therefore, it can be stated that market support enhances information accessibility, household income, decision making capacity and eases access to adaptation inputs.

4.6.1.3 Farm Production Adaptation Strategies

The study also sought to establish farm production adaptation strategies employed by smallholder vegetable farmers. The results as shown in Table 4.17 revealed that (M=4.00, SE=0.07) used high yield water sensitive crops, (M=3.85; SE=0.08) changed planting and harvesting timing, (M=3.82, SE=0.08) planting trees, (M=3.79, SE=0.09) practiced mulching, (M=3.78, SE=0.08) used mixed cropping, (M=3.77, SE=0.08) planted multiple vegetable varieties, (M=3.77, SE=0.08) used crop boosters, (M=3.76, SE=0.09) planted drought resistance varieties, (M=3.50, SE=0.10) burying crop residues and (M=3.18, SE=0.10) practiced crop rotation.

Table 4.17: Farm Production Adaptation Strategies

Variable	Min	Max	Mean	Std. Err	Std. Dev
Mulching	1.00	5.00	3.79	0.09	1.22
Using crop rotation	1.00	5.00	3.18	0.10	1.37
Applying crop boosters	1.00	5.00	3.77	0.08	1.10
Using mixed cropping	1.00	5.00	3.78	0.08	1.13
Changing planting & harvesting Timing	1.00	5.00	3.85	0.08	1.07
Planting high yield water sensitive crops	1.00	5.00	4.00	0.07	1.06
Planting drought resistant varieties	1.00	5.00	3.76	0.09	1.25
Planting trees	1.00	5.00	3.82	0.08	1.14
Selling household Assets to buy farm inputs	1.00	5.00	3.38	0.08	1.11
Planting multiple vegetable varieties	1.00	5.00	3.77	0.08	1.10
Burying crop residues to replenish soil fertility	1.00	5.00	3.50	0.10	1.39
Overall mean			3.69	0.04	0.63

Source: Author's Compilation (2021)

From the findings, it is clear that farmers (mean 3.79) used mulching as an on-farm adaptation strategy to cope with climate variability and its impacts. Here, farmers covered vegetable gardens with grass, planted residues, maize stalks and leaves to

prevent soil moisture deficiency. Mulching helped to conserve soil moisture in the event of drought by preventing water from evaporating, holds soil particles together thus increasing resistance to surface water run-off and lowering of the occurrence of soil erosion. In addition, mulching inhibits and suppresses the growth of weeds such as black jacks which would otherwise compete with vegetable crops thus promoting the growth of vegetables during harsh climatic conditions. The finding of this study is consistent with Mubiru *et al.* (2018) who observed that farmers in Rakai and Hoima districts Uganda used mulching and this helped to absorb some of the sun's rays and slowed the temperature increase of the soil.

From the survey, it is clear that the least employed (mean 3.18) farm production adaptation strategy is crop rotation. This involved growing of different types of crops in the same area across a sequence of growing seasons in order to reduce the development of resistant pests and weeds, enhance soil nutrients and thus minimize crop dependency on external inputs. The low usage of crop rotation is associated with limited crop rotation knowledge and skills among farmers meaning that farmers some farmers did not enjoy benefits accruing from the farm production technique. The finding of this study is negated by Onyeneke and Madukwe (2010) that in the southeast rainforest zone of Nigeria use of crop rotation was popular among most crop farmers and this helped to conserve soil moisture and nutrients in light of frequent droughts.

The findings also revealed that respondents (mean 3.77) used crop boosters to cope with the adverse effects of climate variability. This involved the application of liquid foliar fertilizers containing well-balanced vital nutrients in order to boost crop growth and thus improve livelihood. This was aimed at replenishing minerals required to induce vegetable growth and faster crop recovery from unfavorable climatic conditions by

combating soil infertility thus achievement of adequate vegetable production. The finding of this study is supported by Odewumi *et al*. (2013) who noted that urban farmers in Ibadan Metropolis southwestern Nigeria, applied crop boosters to improve and enhance vegetable yield in the face of climate variability. In addition, Gbegbelegbe *et al*. (2017) reported that in the Agro-Ecological Zones (AEZs) of Ethiopia, Uganda, Tanzania and Kenya, the use crop boosters was a common adaptation strategy by farmers.

Results as shown in Table 4.17 further revealed that smallholders farmers practiced mixed cropping (mean 3.78) as a farm production adaptation strategy to cope with adverse seasonal climatic variations. This involved mixing of less productive, drought resistant varieties and high yield water sensitive crops (plate 4.5) in order to benefit from certain vegetable varieties in case of pests and disease damage to other crops as crops have different levels of resilience to pests and diseases attack. In addition mixed cropping would help farmers harvest at different times of the year and at the same time improve food availability from a small piece of land.

Plate 4.5: Showing mixed cropping in peri-uban Kawempe division

Source: Author (2021)

The finding of this study concurs with previous findings for instance, Kaushik and Kaushik (2014) stated that in India farmers practiced carefully selected mixed cropping

at the farm level in order to optimize production, reduce risk of crop failure, increase total crop harvest and maximize the microclimate. In addition, the finding of the study concurs with Yaro *et al*. (2016) who also reported that in Nigeria's peri-urban Calabar mixed cropping was one of the mechanisms farmers used to cope with the negative impact of climate variability and this aided different crops to support each other.

Further, the study sought to find out whether farmers used changing of planting and harvesting timing as a farm production adaptation strategy. It was established from the study that changing of planting and harvesting timing was the fourth employed farm adaptation strategy (mean 3.85). This therefore, implies that farmers did not plant vegetables on a single date as it may have been the case under normal planting seasons. This was aimed at ensuring that the critical crop growth stage does not coincide with very harsh conditions in the season thus achieving adequate food supply. In Uganda, the first planting season ranges from March to July while the second planting season ranges from August to January (Sabiiti *et al*., 2014). The finding is supported by Kumar and Sidana (2018) who revealed that in Punjab, changing planting and harvesting timing is one of the farm level adaptation strategies and the practice assisted farmers to maximize crop yield. In addition, the finding of the study concurs with Mubiru *et al*. (2018) who found that changing planting dates characterized the farming system in Uganda and aided farmers to cushion against climate variability. In support, Bradshaw *et al*. (2004) revealed that in the Canadian Prairies farmers use multiple planting and harvesting dates as a farm level adaptation strategy to escape unavoidable damages caused by harsh climate conditions.

From the findings, it is clear that most farmers (mean 4.00) planted high yield water sensitive crops as a farm production adaptation strategy. The large number of

respondents who planted high yield water sensitive crops can be closely linked to the intensification of drought regimes in Kampala district as a result of climate variability. This therefore implies that planting high yield water sensitive crops was employed by vegetable farmers to ensuring household survival throughout the year. The result of this study is in line with Deressa *et al*. (2009) who reported that in Ethiopia's Nile Basin planting of high yield crops was an adaptation method and its adoption was determined by factors such as access to financial resources, labour and land.

Further, the survey as shown in Table 4.17 revealed that farmers (mean 3.76) planted drought resistant crops to cope with the negative impacts of climate variability. The strategy involved planting those crops that can thrive well and tolerate drought periods and this helped to support household food shortfalls especially during the stress periods thus ensuring farmers livelihood. The results of this study corroborate with Campbell *et al*. (2011) who observed that farmers in southern St. Elizabeth Jamaica were susceptible to drought incidences and thus used drought tolerant crops as a response to drought hazards. In addition, the finding is supported by Antwi-Agyei *et al*. (2014) who reported that households in northeast Ghana plant drought tolerant crops to confront climatic and non-climatic challenges and use other strategies such as changing the timing of planting, irrigation, planting early maturing varieties of crops in an attempt to reduce the negative impact of climate variability on livelihoods. The idea behind planting drought resistant crops is to increase likelihood of adaptation because the impacts of drought are usually very severe and can push more people into poverty.

The study also found that farmers (mean 3.82) used planting trees to counteract the negative impact of climate change and variability. This involved planting tree crops in and around vegetable gardens to reduce the negative impact of strong wind storms that

blow away vegetable crops. The planted trees would also help to provide shade against harsh temperatures, accelerate the amount of organic matter in the soil thus increase soil fertility throughout the season. The technique reduces exposure to the risks of damage and promotes livelihood. The finding concurs with Acquah-de Graft and Onumah (2011) who revealed that in Ghana planting tree crops was the main climate variability adaptation measure employed by farmers to shield against the effects of climate variability.

The study further established that farmers (mean 3.38) sold household assets as an adaptation strategy. This involved selling of extra household assets and using proceeds of sale to purchase adaptation requirements such as seedlings, fertilizers and crop boosters. This therefore, implies that assets act as insurance against emergencies and are essential determinants of whether a farmer is or will be resilient to climate variability or not as the action helps to stabilize incomes and livelihood of smallholder farmers. This finding is supported by a key informant who emphasized that selling household assets is one of the actions undertaken by farmers to cope with climate variability as he noted;

> *"During hard times caused by climate variability, vegetable farmers sell-off their household assets such as crop harvests, livestock like pigs, chicken and goats to generate income to buy vegetable seedlings, varieties, organic fertilizers and many other agricultural inputs"* (NAADS official, 2021).

The finding of this study concurs with Gbegbelegbe *et al*. (2017) who found that selling of assets such as firewood, household labour and livestock was the fifth most common adaptation strategy employed by farmers in Uganda, Kenya, Tanzania, and Ethiopia. The finding of this study is supported by Mogues, 2011 (as cited in Ogada *et al*., 2020) who observed that rural households in Ethiopia tend to store their wealth in form of livestock especially in the absence of credit whereby livestock especially small

ruminants can easily be sold off to smooth income and consumption fluctuations occasioned by weather shocks whose effects are expected to be larger for poorer households. Assets are means that give people the capability to be and act and generate economic, psychological and social benefits during climatic shocks thus fostering resilience and livelihood.

The study established that farmers planted a variety of vegetables (mean 3.77) as an adaptation strategy. Here, farmers planted early maturing and high value crops during the planting season. This helped farmers to spread pests and disease risks and served as insurance so that farmers benefit from certain vegetable varieties even in case of loss and damage to some, as crops have different levels of resilience. The finding is in line with Yaro *et al*. (2016) who found that farmers in Nigeria's peri-urban Calabar planted different crop varieties as an adaptation mechanism to shield themselves against the impact of climate variability.

Results as shown in Table 4.17 further revealed that smallholder farmers practiced burying of crop residues (mean 3.50) as a farm production adaptation strategy to cope with adverse seasonal climatic variations and this means that farmers were committed to boost vegetable production and livelihood through soil fertility enhancement. The finding concurs with Lema and Majule (2009) who revealed that farmers in Kamenyanga and Kintinku in Manyoni District Tanzania used burying and burning of crop residues to replenish soil fertility, enhance quick release of nutrients as well as allowing livestock to graze on farmlands after harvesting crops so as to improve soil organic matter.

4.6.1.4 Financial Management Adaptation Strategies

The study sought to establish financial management adaptation strategies employed by smallholder vegetable farmers. The results are presented in Table 4.18.

Table 4.18: Financial Management Adaptation Strategies

Variables	Min	Max	Mean	Std. Err	Std. Dev
Farm budgeting	1.00	5.00	4.00	0.08	1.09
Paying loan on time	1.00	5.00	3.79	0.09	1.26
Borrowing money from financial institutions	1.00	5.00	3.78	0.08	1.10
Insuring vegetable farm	1.00	5.00	3.77	0.08	1.13
Saving a percentage of income generated from vegetable farming	1.00	5.00	3.85	0.08	1.07
Engaging in other economic activities	1.00	5.00	4.14	0.07	1.06
Overall mean			3.89	0.04	0.61

Source: Author's Compilation (2021)

From the survey, farmers (mean 4.00) practiced farm budgeting to reduce the negative impact of climate variability. This involved estimating on paper the quality and quantity of farm inputs and sources of finance so as to make careful financial decisions before committing scarce resources, use resources appropriately, minimize wastage and thus increase resilience to climate adaptation. The high preference for farm budgeting is associated to farmers quest for answers to questions such as; which vegetables to plant? When to plant? How much to plant? How much is needed? How much income will be generated? And what will be the source of finances for the adaptation actions? This finding is supported by a key informant who noted;

> *"Due to high costs of farm inputs, limited capital, volatility in commodity markets, challenges posed by Covid 19 and environmental shocks financial risk management skills have become very important to vegetable farmers. So when a farmer sits down and carefully*

> *budgets for his or her vegetable garden, she will list down inputs and also techniques required; will analyze benefits and costs of each input; and also has to analyze the cost for major changes in production techniques. Practices like budgeting and book keeping result in minimization of crop loss and wastage loss which puts farmers on a safe side during unfavorable weather conditions"* (KCCA official, 2021).

Results as shown in Table 4.18 further revealed that smallholders farmers paid loans on time (M=3.79) as a financial management adaptation strategy to cope with adverse seasonal variations. This therefore implies that paying loans on time increased farmers' likelihood of accessing more credit during climate variability and its associated negative consequences thus increasing farmers' adaptive capacity. This finding is supported by a key informant who noted;

> *"Farmers accessed loans to buy farm inputs and to implement changes in farming practices. And if one paid back his or her loan in good time future borrowing becomes smooth…… However, farmers are faced with challenges of crop failure, high cost of inputs, low prices of harvested crops and unforeseen floods and droughts which make loan repayment a daunting responsibility"* (NAADS official, 2021).

Survey results further revealed that farmers (mean 3.78) borrowed money from financial institutions as an adaptation strategy to cope with the negative effects of climate variability. This involved farmers applying for loans and granting successful applicants who used the loans to meet farm adaptation needs such as purchasing of farm inputs, technologies before and during seasonal variations. In addition, borrowing from financial institutions was aimed at helping farmers benefit from a more regular cash flow during difficult times that pose cash constraints. The finding of this study is supported by Ssonko and Nakayaga (2014) who revealed that farmers in Mukono District Uganda borrowed money from micro finance institutions, government aided schemes and commercial banks in order to initiate and implement changes in farming practices. The finding of this study is negated by interview data which revealed that due

to lack of a good financial structure within KCCA most farmers sought loans from friends, relatives, farmers' groups and neighbours. It can be argued that access to financial credit influences implementation of technological developments and on-farm adaptation practices thus leading to an increase in vegetable production, productivity and improved livelihood.

Results as shown in Table 4.18 further revealed that farmers (mean 3.77) used crop insurance to cope with the negative consequences of climate variability. The smaller number of farmers using crop insurance can be closely linked to farmers' ignorance and high cost of crop insurance. In addition, the low usage of crop insurance can be associated to the small number of farmers and small size of vegetable gardens which hinder insurance companies from offering services to smallholder farmers. With such a low utilization of crop insurance, it means that in case of adverse weather conditions the chance of farmers stabilizing their incomes was low thus a reduction in implementation of adaptation technologies. Use of crop insurance would help cover crops against loss or physical damage and this would assist in achieving stability of vegetable farming thus stability of household livelihood. The finding of the study concurs with Mbonane (2018), who reported that few farmers in Swaziland insured their crops and a majority did not have knowledge about the adaptation strategy.

Further, the study sought to find out whether farmers used saving as a financial management adaptation strategy. It was established that use of savings (mean 3.85) was employed by farmers to cope with the impact of climate variability. Here, farmers saved a percentage of income generated from vegetable farming. This was aimed at meeting farm adaptation costs thus initiate adaptation practices during extreme weather events.

The finding of this is study is supported by Aryal *et al*. (2021) who found that in India use of savings was the most applied adaptation strategy while in Napal, Ethiopia and Kenya use of savings was among the common adaptation strategies used by households to address anticipated climate change and variability risks

In addition, the survey found that a majority of farmers (mean 4.14) engaged in other economic activities to cope with the negative consequences of climate variability. This was achieved by farmers allocating production assets to more than one income generating activities. The high preference for engaging in other economic activities can be closely linked to frustrations in the agriculture and limited government support which push farmers to engage in other economic activities to gain extra income that can be used in facilitating agriculture adaptation practices. Engagement in other economic activities is motivated by the need to increase supplement household income. In support, a key informant explained;

> *"I have seen smallholder farmers within the city engaging in teaching, hawking, hairdressing, small business, market vending, …….some work with cleaning companies, catering, some are secretaries, shop attendants, shoe venders,……with a purpose to earn income from more than one source"*(KCCA official, 2021).

The finding of this study is supported by Yamba *et al*. (2017) who reported that farmers in Bosomtwe District Ghana engaged in alternative livelihood activities such as petty trading, charcoal production and selling of cooked food, foodstuffs, small household appliances and accessories as a result of crop failure and low yields. In addition, the finding is also supported by Hepworth and Goulden (2008) who noted that adaptation actions taken by households in Uganda involve diversifying livelihoods in order to earn income and obtain food.

4.7 Adaptation Strategies and Smallholder Vegetable Farmers' Livelihood

The study sought to establish livelihood of smallholder vegetable farmers. The results are presented in Table 4.19.

Table 4.19: Livelihood of Smallholder Vegetable Farmers

Variables	Min	Max	Mean	Std. Error	Std. Deviation
Household Income					
Increased income source diversification	1.00	5.00	3.51	0.09	1.27
Increased household net income	1.00	5.00	4.18	0.07	0.95
Increased Financial Independence	1.00	5.00	3.42	0.09	1.34
Increased welfare	1.00	5.00	3.81	0.07	1.01
Household Food Security					
Increased food productivity	1.00	5.00	4.00	0.07	1.06
Increased access to food	1.00	5.00	3.76	0.09	1.25
Increased food stability	1.00	5.00	3.78	0.08	1.13
Household Assets					
Increased asset ownership	1.00	5.00	3.72	0.08	1.08
Sustainable use of NR base	1.00	5.00	3.08	0.10	1.39
Knowledge Acquisition &Application					
Increased knowledge application	1.00	5.00	3.85	0.08	1.07
Increased decision making	1.00	5.00	3.86	0.08	1.08
Livelihood structures & policies					
Increased structures & Institutions	1.00	5.00	3.77	0.08	1.10
Reduced vulnerability	1.00	5.00	3.87	0.08	1.07
Increased livelihood policies	1.00	5.00	3.88	0.07	0.98
Overall mean			3.75	0.05	0.69

Source: Author's Compilation (2021)

4.7.1 Household Income

From the findings, it is clear that farmers income sources increased (mean 3.51) as a result of using adaptation strategies. This therefore implies that adoption of adaptation strategies has a multiplier effect on household income sources through increased productivity and stabilization of household financial base which enable farmers to expand economic activities. An increase in income sources acts as a kind of self-insurance against negative effects of climate variability and thus used to cope with

climate variability. The finding of this study is supported by Balew *et al*. (2014) who observed that in central Ethiopia adaptation to climate change and variability positively affected income diversification. In addition, the finding is supported by Ellis *et al*., 2010 (as cited in Terfa & William, 2018) who reported that adaptation strategies enabled farmers in Northern Nigeria to invest in activities that were likely to contribute to their future income and inadequate application of adaptation strategies constituted a major constraint income diversification.

Results as shown in Table 4.19 further revealed that smallholder farmers household net income increased (mean 4.18, SE=0.07) as a result of applying adaptation strategies. An increase in household income would help in stabilizing farmers' incomes thus addressing poverty. The finding of this study concurs with Mikemina *et al*. (2018) who reported that in the savanna region of Togo farmers income increased as a result of farmers applying adaptation strategies during climate variability. The finding of this study is consistent with Asmare *et al*. (2019) who reported that in the Nile basin of Ethiopia, the farm household's income for those who adopted crop diversification as an adaptation strategy is significantly higher than if they did not adopt, net farm income will increase significantly for non-adopters if they adopt crop diversification than the actual case of non-adoption and adoption increases net farm income by 578.54 Birr per hectare for adopters and 1566.55 Birr per hectare for non-adopters had they been adopters.

Furthermore, the findings indicate that use of adaptation strategies increased financial independence of farmers (mean 3.08). This therefore implies that smallholder farmers obtained income from vegetable farming and were able to meet daily living expenses thus improving livelihood. Financial independence contributes to achievement of

household poverty reduction goals, greater food security and agriculture production. The finding is supported by Ndiaye *et al*. (2018) who reported that adoption of adaptation strategies in Ferlo semi-arid area, northern Senegal enhanced farmers' financial independence and understanding of the challenges faced by smallholder farmers helps boost farmers capacity to increase production and profitability.

From the findings, respondents indicated that household welfare improved as a result of using adaptation strategies (mean 3.81, SE=0.07). This therefore implies that farmers' household consumption expenditure, farm incomes and farmers engagement in social activities at the local community increased. This can be associated to stable income from vegetable farming, multiple jobs off-farm and to reduction in expenditure on food purchases as well as active participation in markets. The findings of this study concur with Afolami *et al*. (2015) who found that in South Western Nigeria the annual per capita consumption expenditure of the adopters was more (₦36,407.8) than that of non-adopters (₦32,969.6) with a significant mean difference of ₦3,438.0 and the incidence of poverty was higher among non-adopters than adopters thus the adopters had a better welfare than the non-adopters. Further, the finding is supported by Asmare *et al*. (2019) who reported that in the Nile basin of Ethiopia, adaptation practices such as crop diversification consequently reduce the total per hectare family labor use and creates more labor time available for either leisure or other activities.

4.7.2 Household Food Security

Further, the survey as shown in Table 4.19 revealed that adaptation strategies increased farmers' food productivity (mean 3.85). This can be closely linked to successful use of soil and water management technologies. Food availability is an essential aspect of livelihood advancement and it leads to food poverty alleviation and reduction in food

expenditure. The finding is in line DiFalco *et al*. (2011) who reported that in the Nile Basin of Ethiopia, the food productivity function of farm households that adapted to climate change and variability was significantly different from the food productivity function of farm households that did not adapt. DiFalco *et al*. (2011) added that in puts such as seeds, fertilizers, manure and labor, access to credit, extension and information were significantly associated with an increase in the quantity produced per hectare by the farm household that adapted to climate change.

The study findings also revealed that farmers access to food increased (mean 3.76) as a result of adopting climate variability adaptation strategies. This therefore implies that adaptation strategies offered smallholder farmers' adequate resources such as income, land and assets for producing appropriate nutritious and safe food for their household members. Agriculture adaptation strategies play a key role towards achievement of Sustainable Development Goal No. 2. The finding concurs with Hampwaye *et al*. (2009) who reported that adaptation to climate variability in Zambia increases household access to food and that the Zambian government ought to support farmers' adaptation efforts as a strategy to end hunger and malnutrition.

Findings also revealed that adaptation practices led to an increase in food stability (M=3.78, SE=0.08). This therefore implies that implementation of adaptation strategies improved farmers food stability through their impact on micronutrients in the soil, vegetable productivity and adaptation knowledge. In line with the findings, Diallo *et al*. (2020) found a significant positive association between household food stability status and planting of short duration crops and use of organic fertilizers and the strategies reduced food insecurity. In addition, the finding of this study is supported by Ndiaye *et al*. (2018) who found that climate change adaptation strategies adopted by

households in Ferlo semi-arid zone northern Senegal positively correlated with household food stability through increased food productivity thus contributing to poverty alleviation. Further, the findings of the study are consistent with Alhassan (2020) who found that adapting to flood events using both on-farm and non-farm strategies had a positive significant effect on per capita food expenditure among households in the Upper East region Ghana and that on-farm practices such as adoption of improved farm technology leads to higher productivity which enhances households' food security as majority of the farmers in the study area depend largely on their own farm produce for household food consumption.

4.7.3 Household Assets

From the findings it was established that the ownership of household assets increased (mean 3.42, SE=0.09) as a result of using adaptation strategies. This therefore implies that farmers owned irrigation equipment, household items, livestock and hired land for cultivation thus increasing household future levels of income, food security and economic well-being. In support, a report by Lerman and McKernan (2008) states that the central role of assets is to cushion the decline in consumption which might arise with a sudden income loss emanating from shocks, to contribute to household stability, reduce tension and results in a sense of control during hard times. Therefore it can be argued that adaptation to climate variability leads to acquisition of household assets which in turn provide benefits necessary in adaptation and farmers livelihood.

Results as shown in Table 4.19 further established that adaptation strategies led to increased sustainable use of natural resources (mean 3.72, SE=0.08). This involved protecting natural resources such as water sources (plate 4.6) to ensure that the resources continue to meet household and farm water needs during harsh climatic

conditions such as drought. This implies that ecological assets are significant for smallholder farmers living in urban areas bearing in mind the direct and indirect impact of increased drought periods and associated water scarcity. Sustainable use of natural resources helped to enhance the ability of natural systems to continue to provide the natural resources and ecosystem services upon which the farming depends thus achieving farming goals.

Plate 4.6: Showing a Water Source near a Vegetable Garden in Kawempe Division

Source: Field Results (2021)

The finding is in line with Eriksen and O'brien (2007) who stated that adaptation measures such as improved techniques of water conservation contribute to reducing risk and strengthening of livelihoods of the poor people who always seek to protect well-being in the face of droughts and floods and on-farm planting of indigenous trees enhances the viability of forest-based livelihood options.

4.7.4 Knowledge Acquisition &Application

The study established that adoption of climate variability adaptation strategies increased knowledge application (M=4.00, SE=0.07) among farmers. This therefore implies that adaptation strategies enabled farmers to understand and relate new agriculture techniques and technologies used in climate adaptation through extension services, demonstration units. The finding is negated by Al-Zaidi e*t al*. (2016) who found that majority of farmers' knowledge application levels in Udeen area Yemeni ranged between low and medium and this is attributed to the decline in crop production and low rank at the international level.

The study findings also revealed that farmers decision making improved as a result of using adaptation mechanisms (mean=3.86 SE=0.08). This implies that utilization of adaptation resources such as information, technologies, capital changed farmers' behaviour in terms of long-term planning and participation in farm level decisions. The finding is supported by Mikemina *et al*. (2018) who reported that in Savana region Togo adaptation is a continuous decision making process which involves making good decisions in the face of climate variability uncertainties thus increasing farmers' efficacy in farming activities. It can be argued that decision making is a vital component of adaptation and livelihood of farmers and starts with farmers' perception of climate variability and choosing of adaptation actions.

4.7.5 Livelihood Structures & Policies

Furthermore, the survey found that structures and institutions to support urban vegetable farming increased (mean 3.87 SE=0.08). Kyanja agricultural resource center located in Kawempe division was established with a purpose of demonstrating innovations and encourage communities to participate in urban farming as a source of

income and food security. The establishment of functional institutions and structures was aimed at enhancing farmers' means of survival, produce and reproduce development through supporting urban farming practices thus achievement of sustainable urban livelihoods and communities. According to O'Riordan and Jordan (1999) institutions are means for holding societies together giving a sense and purpose and enabling it to adapt| to shocks by facilitating supervision of current climate related risks and building institutional capacity to address future climate change and its impacts.

The study found that adaptation decisions enhanced formulation of livelihood policies (mean 3.88, SE=0.07). In line with the policies, farmers in Kampala district are given technical knowledge, inputs and regular weather forecasts and climate information by NAADS and Uganda Meteorological Authority to bolster adaptation and farmers livelihood. This means that Uganda recognizes the need for sustainable livelihoods of its people through agriculture and climate change policies. For instance, Uganda has ratified national and international conventions on climate change and adaptation and signed the United Nations Framework Convention for Climate Change in 1992 and ratified it on 8 September 1993 (Abwooli *et al*., 2014). At the national level Uganda adopted her disaster preparedness and management policy (DPM) in 2010; environment policy (1995), energy policy (2002); the National land use policy (2007); National water policy (1997); Draft climate change policy (2012) which states that adaptation to climate change in Uganda requires a series of coordinated policy responses that are either sector specific or cross-cutting in nature" (Nyasimi *et al*., 2016; Abwooli *et al*., 2014).

The study findings also revealed that respondents vulnerability to climate change and extreme events reduced (mean 3.77, SE=0.08) upon using adaptation strategies. This can be closely associated to the advantages and efficacy of adaptation measures employed by smallholder farmers to bolster sustainable adaptation and thus livelihood. The finding of this study concurs with the United Nations (2019) which notes that adapting to climate change entails taking the right measures to reduce vulnerability. Amidst exposure to climate change provocations, the goal of climate variability adaptation strategies, is to reducing farmers' vulnerability and enhance their livelihood. On the contrary, Eriksen *et al*. (2021) found that some adaptation strategies reinforce existing vulnerability through elite capture and others simply redistribute vulnerability over a broader spatial area. Eriksen *et al*. (2021) argue that some adaptation efforts introduce new risks and sources of vulnerability for instance increased irrigation may reduce water availability for domestic and other purposes.

In summary, findings on livelihood of respondents indicate that smallholder farmers' livelihood improved as a result of adopting adaptation strategies. It is worth noting that the study has revealed various interlinked factors that influence farmers' adaptation decisions and consequently their livelihood. Most of the time policy makers and development interventions focus on introducing strategies and give little attention to their effects on livelihood.

4.8 Factor Analysis

4.8.1 Factor Analysis for Technological Development Adaptation Strategies

The factor analysis results for technological development adaptation strategies as shown in Table 4.20 revealed that the KMO was 0.625 indicating that sampling was adequate, Bartlett's Test of sphericity was significant ($p<0.05$) and chi-square value

was 217.779 thus confirming that the data collected for technological development adaptation strategies was adequate.

Table 4.20: KMO and Bartlett's Test for Technological Development Adaptation Strategies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.625
Bartlett's Test of Sphericity	Approx. Chi-Square	217.779
	Df	10
	Sig.	.000

Source: Author's Compilation (2021)

In addition, principal component analysis, using varimax rotation method revealed that two factor components were extracted, four items loaded virtually exclusively on factor component one (1) while one item loaded substantially on factor component two (2). Thus, technological development adaptation was measured using the five items derived from Rotated component matrix as shown in (Appendix I).

Further, the study used total variance to interpret the variance accounted for by each component in government agricultural support. Varimax rotation was used to maximize the sum of the variance of the squared component factors for technological development adaptation strategies. The results as shown in Table 4.20 revealed that the two principal component factors accounted for 67.17% of the variance in rotation sums of squared components associated with the factors where; factor one (1) explained 45.577% and factor 2 explained 21.596% of the variance in the data.

Table 4.21: Total Variance for Technological Development Adaptations Strategies

Component	**Rotation sums of squared loadings**		
	Total	% of Variance	Cumulative %
1	2.279	45.577	45.577
2	1.080	21.596	67.174

Extraction Method: Principal Component Analysis.

Source: Author's Compilation (2021)

4.8.2 Factor Analysis for Government Agricultural Support

The factor analysis results for government agricultural support as shown in Table 4.21 revealed that the KMO was 0.590 indicating that sampling was adequate, Bartlett's Test of sphericity was significant ($p<0.05$) and a chi-square value was 93.04 thus confirming that data collected for government agricultural support was adequate.

Table 4.22: KMO and Bartlett's Test for Government Agricultural Support

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.590
Bartlett's Test of Sphericity	Approx. Chi-Square	93.037
	Df	10
	Sig.	.000

Source: Author's Compilation (2021)

In addition, principal component analysis using varimax rotation method results indicated that two factor components were extracted, two items loaded exclusively on factor component one (1), while three items loaded substantially on factor component two(2). Thus, government agricultural support was measured using a total of five items as shown in (Appendix II).

Further, varimax rotation was used to maximize the sum of the variance of the squared component factors for government agricultural support. The results as shown in Table 4.23 revealed that the first factor explained 30.512% and the second factor explained 28.165% of the variance in the data. Thus, the two principal component factors accounted for 58.677% of the variance in rotation sums of squared components associated with the factors.

Table 4.23: Total Variance for Government Agricultural Support

Component	Rotation Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**
1	1.526	30.512	30.512
2	1.408	28.165	58.677

Extraction Method: Principal Component Analysis.

Source: Author's Compilation (2021)

4.8.3 Factor Analysis for Farm Production Strategies

The factor analysis results for farm production strategies as shown in Table 4.24 revealed that KMO value was 0.765 indicating that sampling was adequate, Bartlett's test of sphericity was significant ($p<0.05$) and chi-square value was 998.72 confirming that data collected for farm production strategies was adequate.

Table 4.24: KMO and Bartlett's Test for Farm Production Strategies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.765
Bartlett's Test of Sphericity	Approx. Chi-Square	998.719
	Df	78
	Sig.	.000

Source: Author's Compilation (2021)

In addition, from the rotated component matrix four-factor components were extracted; the first four items loaded substantially on factor component one (1), three items loaded on factor component two (2), two items loaded on factor component three (3) and finally two items loaded substantially on factor component four (4). Therefore, farm production adaptation was measured using a total of 11 items as shown in (Appendix III).

Further, varimax rotation was used to maximize the sum of the variance of the squared component factors for farm production adaptation strategies. The results as shown in

Table 4.25 revealed that the first factor explained 24.883%, the second factor explained 20.052% of the variance, third factor explained 13.124% of the variance and finally the fourth factor explained 11.782% of the total variance in the data. Thus, the four principal component factors accounted for 69.841% of the variance in rotation sums of squared components associated with the factors.

Table 4.25: Total Variance for Farm Production Strategies

Component	Rotation Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**
1	2.737	24.883	24.883
2	2.206	20.052	44.935
3	1.444	13.124	58.059
4	1.296	11.782	69.841

Extraction Method: Principal Component Analysis.

Source: Author's Compilation (2021)

4.8.4 Factor Analysis for Financial Management Adaptation Strategies

The factor analysis results for farm financial adaptation strategies as shown in Table 4.26 revealed that the KMO value of financial management adaptation strategies was 0.662 indicating that sampling was adequate, Bartlett's Test of sphericity was significant ($p<0.05$) and chi-square value was 192.171thus confirming that data collected for financial management adaptation strategies was adequate.

Table 4.26: KMO and Bartlett's Test for Financial Management Adaptation Strategies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.662
Bartlett's Test of Sphericity	Approx. Chi-Square	192.171
	Df	15
	Sig.	.000

Source: Author's Compilation (2021)

In addition, rotated component matrix contained the rotated factor loading, which represented both how the variables were weighted for each factor. From the rotated component matrix**,** two factor components were extracted; four items load substantially on factor component one (1) while two items load substantially on factor component two (2). Therefore, financial management adaptation was measured using six items as shown in (Appendix IV).

Furthermore, the study used total variance to interpret the variance accounted for by each component of farm financial management adaptation strategies. Varimax rotation was used to maximize the sum of the variance of the squared component factors for farm financial management adaptation strategies. The results as shown in Table 4.27 revealed that the two principal component factors accounted for 58.830% of the variance in rotation sums of squared components associated with the factors where; factor one (1) explained 36.487% and factor 2 explained 22.343% of the variance in the data.

Table 4.27: Total Variance for Financial Management Adaptation Strategies

Component	**Rotation Sums of Squared Loading**		
	Total	**% of Variance**	**Cumulative %**
1	2.189	36.487	36.487
2	1.341	22.343	58.830

Extraction Method: Principal Component Analysis.

Source: Author's Compilation (2021)

4.8.5 Factor Analysis for Livelihood of Smallholder Vegetable Farmers

The factor analysis results for livelihood of smallholder vegetable farmers as indicated in Table 4.28 revealed that the KMO value was 0.834, Bartlett's Test of sphericity was significant ($p<0.05$) and chi-square value was 1209.08 which confirmed that data collected for livelihood was adequate.

Table 4.28: KMO and Bartlett's Test for Livelihood of Smallholder Vegetable Farmers

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.834
Bartlett's Test of Sphericity	Approx. Chi-Square	1209.08
	Df	91
	Sig.	.000

Source: Author's Compilation (2021)

Using the rotated component matrix**,** fourteen items were extracted, and loaded substantially on four component factors. The first five items loaded substantially on factor component one (1), four items loaded on factor component two (2), three items loaded on factor component three (3) and lastly two items loaded on factor component four (4). Therefore, livelihood of smallholder vegetable farmers was measured using a total of fourteen items as shown in (Appendix V).

Varimax rotation was used to maximize the sum of the variance of the squared component factors for farm financial management adaptation strategies. The results as shown in Table 4.29 revealed that the four principal component factors accounted for 66.929% of the variance in rotation sums of squared components associated with the factors where; factor one (1) explained 22.713%, factor 2 explained 17.038%, factor three explained 14.533% and factor four explained 12.645% of the variance in the data.

Table 4.29: Total Variance for Livelihood of Smallholder Vegetable Farmers

Component	**Rotation Sums of Squared Loading**		
	Total	**% of Variance**	**Cumulative %**
1	3.180	22.713	22.713
2	2.385	17.038	39.751
3	2.035	14.533	54.284
4	1.770	12.645	66.929

Extraction Method: Principal Component Analysis.

Source: Author's Compilation (2021)

4.9 Correlation Analysis of the Variables

The study used Pearson correlation coefficient to determine the relationship between each adaptation strategy and livelihood of vegetable farmers. Results of correlation analysis are presented in Table 4.30.

Table 4.30: Correlation Analysis of the Variables

Variables		1	2	3	4	5
1.Livelihood	Pearson Correlation	1	.848**	.810**	.773**	.423**
	Sig. (2-tailed)		.000	.000	.000	.000
2.Technological	Pearson Correlation	.810**	.788**	1	.781**	.555**
	Sig. (2-tailed)	.000	.000		.000	.000
3.Government	Pearson Correlation	.423**	.441**	.555**	.406**	1
support	Sig. (2-tailed)	.000	.000	.000	.000	
4. Farm production	Pearson Correlation	.848**	1	.788**	.831**	.441**
	Sig. (2-tailed)	.000		.000	.000	.000
5. Financial	Pearson Correlation	.773**	.831**	.781**	1	.406**
	Sig. (2-tailed)	.000	.000	.000		.000

Notes: Correlation is significant at the 0.01 level (2-tailed).
b. Listwise N=201

Source: Author's Compilation (2021)

4.9.1 Technological Development Adaptation Strategies and Livelihood of Farmers

The study results (r= 0.810, p =0.000) revealed that there was a positive and strong correlation between technological adaptation strategies and livelihood of smallholder vegetable farmers. This therefore implies that adoption of technological adaptation strategies enhanced farmers' capacities to generate and maintain their means of living. The finding is supported by Ogada *et al*. (2020) who reported that a positive correlation existed between use of climate smart agriculture technologies and asset index, household income. In support, Osewe *et al*. (2020) reported that adoption of

technological innovations such as farmer-led irrigation created a significant positive effect on smallholder farmers' per capita net crop income in Kilolo and Mbarali districts in Southern Tanzania.

4.9.2 Government Support Programs and Livelihood of Farmers

Furthermore, analysis of correlation of government support programs with livelihood of vegetable farmers revealed a significant positive and moderate correlation ($r = 0.423$, $p = 0.000$). This means that an increase in government support resulted in an increase in farmers' livelihood but in a moderate manner. The positive but moderate relationship between government support and livelihood can be closely linked to limited access, high cost and provision of government support in peace meals. This therefore implies that government support programs were not adequate enough to guarantee improvement in farmers' livelihood in the face of climate variability. Government agricultural support would benefit poor smallholder farmers who are the most vulnerable and less able to cope with the impact of climate variability. The finding of this study is supported by Sonam *et al*. (2019) who found a positive but moderate correlation between government support programs and livelihood of farmers in Bhutan where the seed subsidy had a significant impact on income but mainly benefited the non-poor population who had access to it compared to the poor population with limited access to the program. Agriculture is the backbone of Uganda's economy and her agricultural policy has always revolved around increasing productivity, farmers' income, enhanced food security and nutrition, this can be realized prioritizing government agricultural support programs.

4.9.3 Farm Production Adaptations and Livelihood of Farmers

The findings revealed that there was a positive and strong relationship between farm production strategies and livelihood of smallholder vegetable farmers (r=0.848, p =0.00). This means that vegetable farmers engaged in a myriad of farm adaptation practices which influenced smallholder farmers' livelihood in a positive way. This therefore implies that use of farm production adaptation strategies resulted in resources, assets and activities that helped farmers in their pursuit of a worthwhile living. The finding of this study is supported by Mikemina *et al*. (2018) who reported that in Togo the farm income equation of farm households that adopted farm production adaptation strategies was significantly higher than the farm income equation of households that did not adopt as they were able to mitigate at least 63% of the effects of climate change and variability on crops and live-stock income. In addition, the finding of this study concurs with Asmare *et al*. (2019) who reported that in the Nile Basin of Ethiopia the household income of farmers who adopted crop diversification as a farm production adaptation strategy was significantly higher than that of farmers who did not adopt the farm adaptation strategy.

4.9.4 Financial Management Adaptation Strategies and Livelihood of Farmers

Finally, the results (r =0.773, p=0.000) indicate that there was a positive and strong relationship between financial management strategies and livelihood of smallholder vegetable farmers. This means that financial management adaptation strategies helped famers in their quest for a viable living. This could be associated to improved farm business management knowledge and skills that could help farmers meet emergencies and make proper decisions. The finding is supported by Ssonko and Nakayaga (2014) who stated that farm financial practices had a significant relationship with livelihood of farmers. Ssonko and Nakayaga added that financial management helped farmers in

Mukono district to improve farm productivity, increase profitability and fulfill long term goals.

4.10 Diagnostic Tests

Multiple regression analysis was used to test the relationship between climate variability adaptation strategies and livelihood of smallholder vegetable farmers. Prior to running the tests, assumptions of regression were examined. The multiple regressions work best on the basis of certain assumptions (Tabachnick & Fidell, 2013). The construct statements used in the questionnaire were positively worded, coded and entered into SPSS (Version 26) in order to test the assumptions of multiple regression. Data for these variables were consequently examined for regression assumptions; normality, linearity, homoscedasticity, autocorrelation and multicollinearity.

4.10.1 Normality Test

Normality in distribution of data across the five constructs was examined using the quantile–quantile (Q-Q) plots. Loy, Follett and Hofman (2015) observe that Q-Q plots have the ability to point out non-normal features of distributions, making them more suitable for testing normality. In the Q-Q plot, normality was achieved when plotted data representing a given variable followed a diagonal line usually produced by a normal distribution. Livelihood of smallholder vegetable farmers was conceptualized as the dependent variable. The normal Q-Q plot displayed in Figure 4.4 indicates that data dots stayed alongside the diagonal line throughout the distribution implying that data followed a normal distribution.

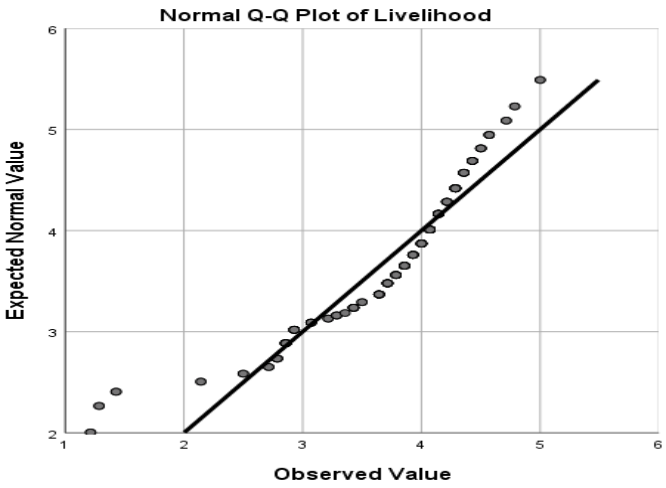

Figure 4.4: Normal Q-Q Plot of Livelihood of Smallholder Vegetable Farmers

Source: Author (2021)

Technological development was the first climate variability adaptation strategy, conceptualized as an independent variable. The normal Q-Q plot of the technological development distribution indicated that normality assumption was not violated. As shown in figure 4.5, the dots generated from the technological development data were close to the diagonal line.

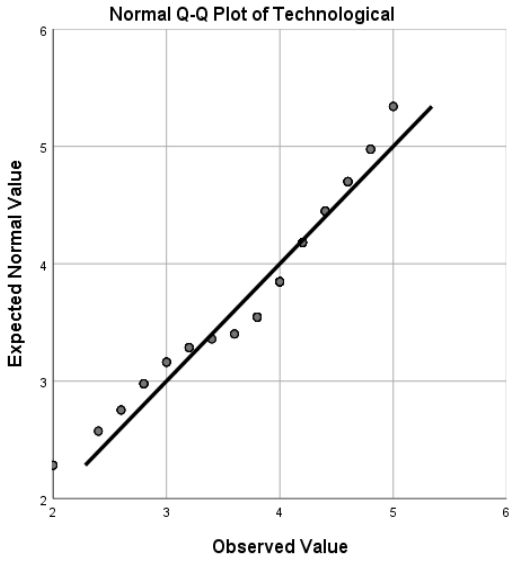

Figure 4.5: Normal Q-Q Plot of Technological Development Adaptation Strategies

Source: Author (2021)

Government agricultural support was identified as the second climate variability adaptation strategy which was conceptualized as an independent variable. The normal Q-Q plot as displayed in Figure 4.6 shows that data were largely along the diagonal line, which signifies that data distribution for government agricultural support was normal.

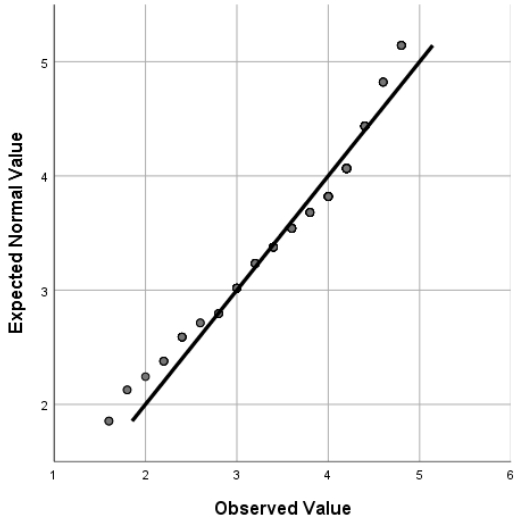

Figure 4.6: Normal Q-Q Plot of Government Support Programs

Source: Author (2021)

Farm production adaptation strategy was identified as the third climate variability adaptation strategy which was conceptualized as an independent variable. The normal Q-Q plot as shown in Figure 4.7 indicates that data were largely along the diagonal line, which signifies that data distribution for farm production adaptation strategies was normal.

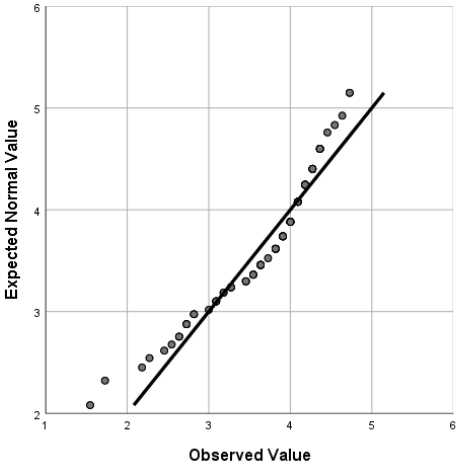

Figure 4.7: Normal Q-Q Plot of Farm Production Adaptation Strategies

Source: Author (2021)

Financial management was identified as the fourth climate variability adaptation strategy conceptualized as an independent variable. The normal Q-Q plot as shown in Figure 4.8 indicates that data were largely along the diagonal line, which signifies that data distribution for financial management to be normal.

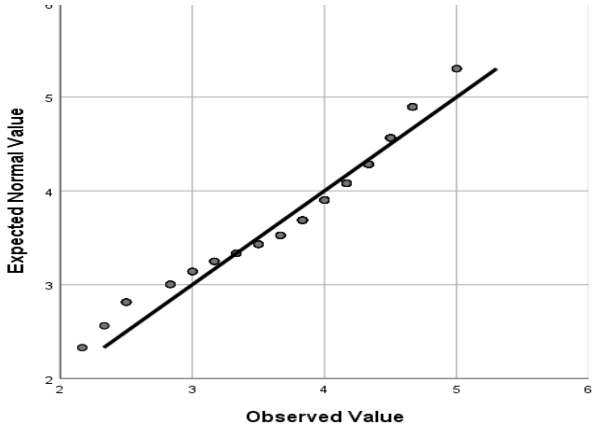

Figure 4.8: Normal Q-Q Plot of Financial Management

Source: Author (2021)

4.10.2 Linearity Assumption Test

The bivariate scatter plots were used to examine the degree of linear relationship among the study variables. Specifically, independent variables were climate variability adaptation strategies; technological development, government agriculture support programs, farm level production and financial management and livelihood of

smallholder vegetable farmers as the dependent variable. Tabachnick and Fidell (2019) recognize linearity as one of the assumptions upon which regression analysis is pegged. As shown in Figure 4.9 linearity of variables was confirmed when elliptical or oval scatter plots were produced.

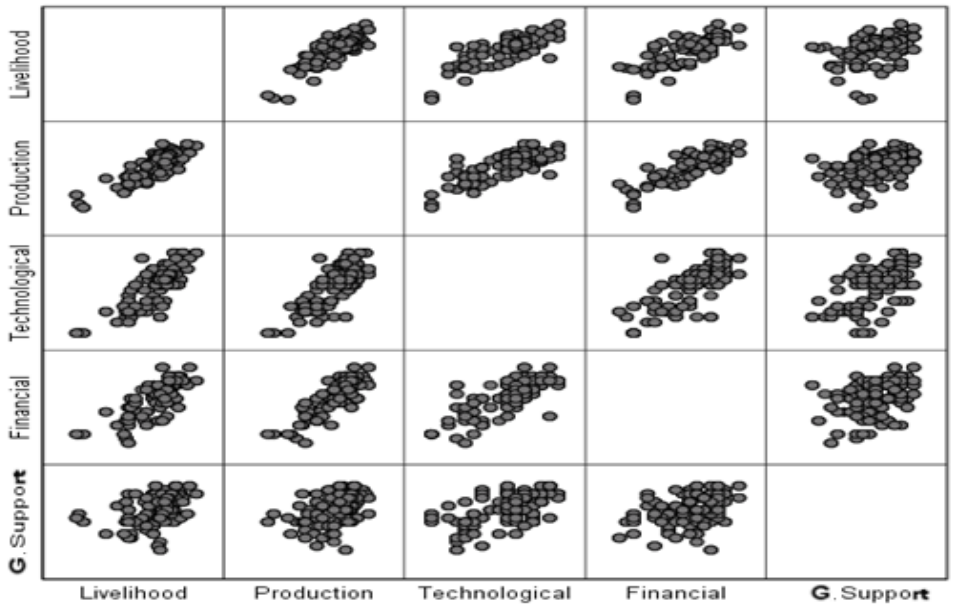

Figure 4.9: Linear Relationship between Variables

Source: Author (2021)

4.10.3 Autocorrelation Test

Autocorrelation as noted by Tabachnick and Fidell (2019) is a measure of correlation among regression residuals. The assumption of independence of errors is violated when factors such as time and distance are associated with the order in which cases are taken. Autocorrelation (independence of errors) was tested using the Durbin–Watson (DW) statistic. Durbin–Watson statistic is regarded as a measure of independence of errors when the order of cases is factored in (Tabachnick & Fidell, 2019). According to Hair *et al*. (2010), regression analysis assumes that regression residuals are independent of one another. Thus, a Durbin–Watson statistic in the range $1.5 \leq d \leq 2.5$ suggests lack of autocorrelation. Consequently, a Durbin-Watson statistic lying within the two critical

values was deemed to signify lack of first order linear auto-correlation in regression data. Results as presented in Table 4.31 reveal that the overall Durbin-Watson statistic d=1.984 was between the two critical values and hence there was no auto-correlation in the data. Results confirms that the Durbin–Watson statistics for each of the four independent variables were in the range $1.6 \leq d \leq 2.0$, an indication of lack of autocorrelation.

Table 4.31: Autocorrelation Test

Model		Durbin-Watson
1	Technological	1.990[a]
	Government Support	1.625[a]
	Farm Production	1.799[a]
	Financial	1.914[a]
	Overall	1.984[a]

a. Dependent Variable: Livelihood

Source: Author's Compilation (2021)

4.10.4 Multicollinearity Test

Multicollinearity is identified as a situation where independent variables or predictors are highly correlated among themselves (Vatcheva, Lee, McCormick, & Rahbar, 2016). In the presence of multicollinearity, it may not be practically possible to assume the interpretation of the regression coefficient as being attributed to one variable, while holding others constant because of the information that could be overlapping. To test for multicollinearity, the Variance Inflation Factor (VIF) and tolerance were used. The rule of thumb for a VIF value should be less than ten and tolerance should be greater than 0.2 (Shieh, 2010). The VIF value as shown in Table 4.32 was 3 which is less than 10 and the least tolerance was 0.26 which is greater than 0.20. Therefore the assumption on multicollinearity was not violated.

Table 4.32: Collinearity Statistics

Model		Collinearity Statistics	
		Tolerance	**VIF**
1	Technological adaptation	.282	3.552
	Government Support	.688	1.453
	Farm Production adaptation	.259	3.860
	Financial management Adaptation	.266	3.756
	Mean VIF		3.155

a. Dependent Variable: Livelihood

Source: Author's Compilation (2021)

4.10.5 Homoscedasticity

Homoscedasticity is an assumption of equal variance of errors across all levels of the independent variables and can be checked using visual examination of a plot of the standardized residuals by the regression standardized predicted value (Osborne & Waters, 2002). While homoscedasticity was checked using the standardized residual scatter plot. The results as shown in Figure 4.10 indicate that standardized residuals concentrated in the centre (around 0) and their distribution was rectangular meaning that variance in the residuals of the dependent variable scores are the same thus homoscedasticity was not a problem.

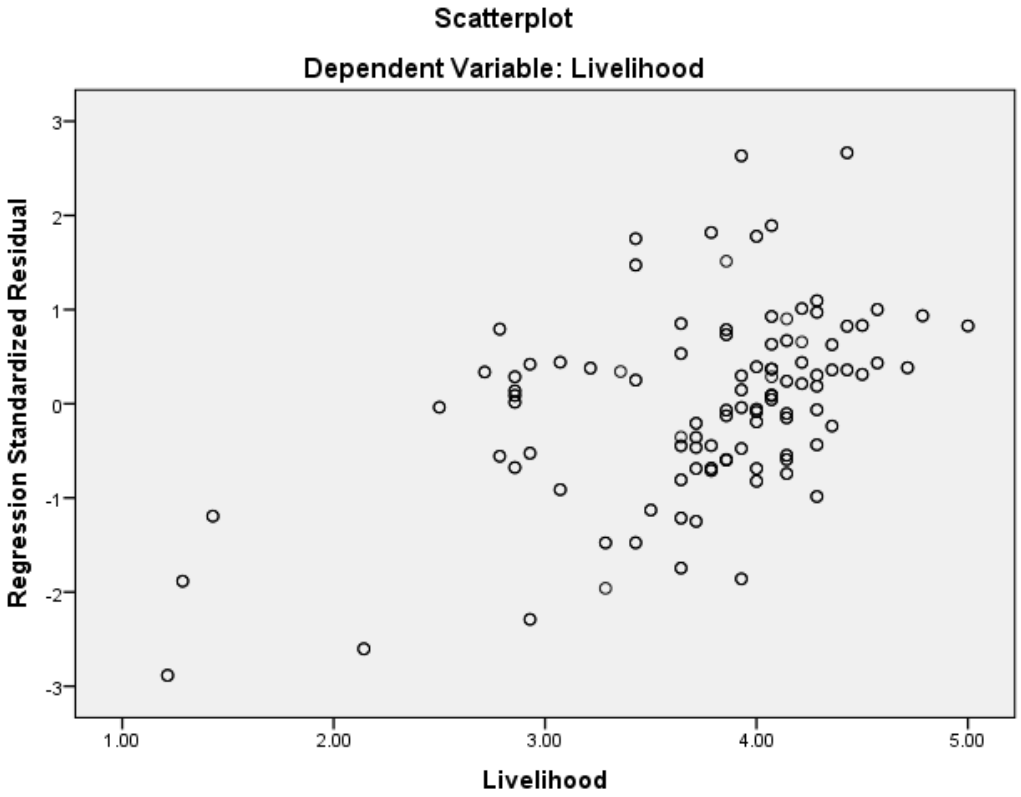

Figure 4.10: Scatterplot of Dependent Variable

Source: Author (2021)

4.11 Multiple Regression Analysis Results

Multiple regression analysis was used to analyze the effect of independent variables on a single dependent variable. The regression coefficient summary was used to explain the nature of the relationship between the independent variables and the dependent variable. Based on the multiple regression model the coefficient of determination (R squared) of .775 indicating that 77.5% of the variation in livelihood of smallholder vegetable farmers can be explained by climate variability adaptation strategies. The adjusted R square of .770 depicts that all the climate variability adaptation strategies in exclusion of the constant variable explained the variation in livelihood of smallholder vegetable farmers by 77% the remaining percentage can be explained by other factors excluded from the model as summarized in Table 4.33.

Table 4.33: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.880[a]	.775	.770	.32917

a. Predictors: (Constant), technological, government support, farm production, financial management.

Source: Author's Compilation (2021)

The analysis of variance was used to test whether the model could significantly fit in predicting the outcome as compared to using the mean. Results (F=168.7, p value=0.000) show that the regression model explains significantly the variation in the dependent variable.

Table 4.34: Analysis of Variance

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	73.119	4	18.280	168.70	.000[b]
	Residual	21.238	196	.108		
	Total	94.357	200			

a. Dependent Variable: Livelihood

b. Predictors: (Constant), government support, financial, technological, farm production adaptation strategies

Source: Author's Compilation (2021)

The β coefficients for climate variability adaptation strategies as independent variable were generated from the model as shown in Table 4.35 in order to test the hypotheses of the study. The t-test was used to identify whether the climate variability adaptation strategies as a predictor was making a significant contribution to the livelihood model.

Table 4.35: Coefficients of Climate Variability Adaptation Strategies

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.146	.164		.888	.375
	Technological Adaptation	.357	.062	.368	5.768	.000
	Government Support	-.037	.039	-.038	-.935	.351
	Farm production	.557	.072	.514	7.716	.000
	Financial management	.082	.073	.074	1.122	.263

a. Dependent Variable: Livelihood

The table shows the estimates of β-value and the contribution of each predictor to the model. The β-value for technological development adaptation strategies, farm production adaptation strategies and farm financial management adaptation strategies had a positive coefficient thus depicting a positive effect while government agricultural support programs had a negative coefficient thus depicting a negative effect on livelihood of smallholder vegetable farmers as summarized in the model as:

Where:

$Y = 0.146 + 0.357X_1 + -0.037X_2 + 0.557X_3 + 0.082X_4 + \varepsilon$ 4.1

Where;

Y= Livelihood
X_1 = Technological development adaptation strategies
X_2 = Government agricultural support
X_3= = Farm production adaptation strategies
X_4 = Farm financial management adaptation strategies
ε = error term
β_0 = Constant coefficient of the model
β_1..... β_4 = regression coefficients of explanatory variables

From the model it is clear that technological adaptation strategies have a positive relationship with livelihood of farmers. This means that a change in technological adaptation strategies increased farmers livelihood by 35.7% thus use of weather forecast and climate information, water harvesting, changing soil conservation technologies, use of water pans for irrigation and planting of a variety of crops all contribute towards improving the livelihood of vegetable farmers.

In addition, government support programs have a negative relationship with livelihood of farmers. This means that a change in government support programs did not increase farmers' livelihood, thus agricultural training, agricultural extension services, subsidized credit, agricultural inputs and market support all did not contribute towards improving the livelihood of vegetable farmers. This is because majority of smallholder vegetable farmers did not get Government agricultural support towards vegetable farming in 2020.

Furthermore, farm production adaptation strategies have a positive relationship with livelihood of farmers. This means that a change in farm production adaptation strategies increased farmers livelihood by 55.7% thus use of mulching, crop rotation, crop boosters, mixed cropping, changing planting and harvesting dates and planting high yield water sensitive crops all contribute towards improving the livelihood of vegetable farmers.

Finally, farm financial adaptation strategies have a positive relationship with livelihood of farmers. This means that a change in farm management adaptation strategies increased farmers livelihood by 8.2% thus use of farm budgeting, paying loans on time, borrowing from financial institutions, insuring vegetable farms, saving, and engaging

in other economic activities all contribute towards improving the livelihood of vegetable farmers.

4.12 Hypotheses Testing

The following hypotheses were tested at 0.05 level of significance: $H_{01:}$ technological development adaptation strategies have no significant effect on smallholder farmers livelihood; $H_{02,}$ government agricultural support has no significant effect on smallholder farmers' livelihood; $H_{03,}$ farm production adaptation strategies have no significant effect on smallholder farmers livelihood; $H_{04,}$ farm financial management adaptation strategies have no significant effect on livelihood of farmers. All the hypotheses were tested using SPSS version 26.

Decision Rule

Given the set level of significance as a=0.05, p-values less than or equal to 0.05 imply reject the null hypothesis. The decision rule for testing the hypotheses was to reject H0 if $p<0.05$ or fail to reject if otherwise.

Null Hypothesis 1: Technological development adaptation strategies have no significant effect on livelihood of smallholder vegetable farmers.

The study hypothesized that there was no significant effect of technological development adaptation strategies on farmers' livelihood. To test this hypothesis, the technological development adaptation strategies were regressed on the livelihood of smallholder vegetable farmers' variable. The multiple linear regression results (β_1=0.357 and p=0.000) as shown in Table 4.35 depicted that $p < 0.05$. Thus the null hypothesis (H_{01}) is rejected. Therefore, technological development adaptation strategies had a significant effect on livelihood of smallholder vegetable farmers in Kampala district Uganda. This implies that for every increase in adaptation of technological

development strategy, there was a corresponding improvement in livelihood of smallholder vegetable farmers in Kampala district.

Null Hypothesis 2: Government agricultural support has no significant effect on livelihood of smallholder vegetable farmers.

The study also sought to establish whether government agricultural support has a significant effect on livelihood of smallholder vegetable farmers. To achieve this, a regression of government agricultural support on livelihood was conducted. The study results (β_2=-0.037 and p=0.351) depicted that $p > 0.005$ thus failed to reject the null hypothesis. Thus the researcher concluded that, there was no significant effect of government agricultural support on livelihood of smallholder vegetable farmers in Kampala district, Uganda. This implies that for every unit increase in government agricultural support, there was no corresponding improvement in livelihood of smallholder vegetable farmers.

Null Hypothesis 3: Farm production adaptation strategies have no significant effect on livelihood of smallholder vegetable farmers.

The study investigated if there was any significant effect of farm production adaptation strategies on livelihood of smallholder vegetable farmers. To test the hypothesis, farm production adaptation strategies variable was regressed on livelihood of smallholder vegetable farmers' variable. The study results (β_3=0.557 and p=0.000) as shown in table 4.34 depicted that $p < 0.05$ thus the null hypothesis (Ho_3) was rejected. The study therefore, concluded that farm production adaptation strategies had a positive significant effect on livelihood of smallholder vegetable farmers in Kampala district. This implies that for every unit increase in farm production adaptation strategies, there

was a corresponding increase in livelihood of smallholder vegetable farmers in Kampala district.

Null Hypothesis 4: Farm financial management adaptation strategies had no significant effect on livelihood of smallholder vegetable farmers.

The study sought to find out whether farm financial management adaptation strategies had a significant effect on livelihood of smallholder vegetable farmers. A regression of farm financial management adaptation strategies variable and livelihood of smallholder vegetable farmers' variable was conducted. The study results (β_2= 0.082 and p=0.263) depicted that farm financial management adaptations variable is positive but not a significant predictor of livelihood because the $p > 0.05$. Thus failed to reject the null hypothesis. This therefore implies that for every unit increase in farm financial management adaptation strategies, there was no corresponding increase in livelihood of smallholder vegetable farmers in Kampala district.

A summary of the hypotheses testing results using multiple regression together with the conclusions are tabulated:

Table 4.36: Summary of Hypotheses Results

Hypothesis	β-value	P-value	Results
H_{01}: Technological development adaptation strategies have no significant effect on livelihood of smallholder vegetable farmers.	β_1=0.357	.000	Rejected
H_{02}: Government agricultural support has no significant effect on livelihood of smallholder vegetable farmers.	β_2= -0.037	.351	Accepted
H_{03}: Farm production adaptation strategies have no significant effect on livelihood of smallholder vegetable farmers.	β_3=0.557	.000	Rejected
H_{04}: Farm financial management adaptation strategies had no significant effect on livelihood of smallholder vegetable farmers.	β_4=0.082	.263	Accepted

Source: Author's Compilation (2021)

The results shown in Table 4.36 above reveal that after testing the four hypotheses, hypotheses H_{01} and H_{03} are rejected. It was observed that the p-values were less than the set significance level of a=0.005. Thus, because the p-values were less than 0.05, the null hypotheses are rejected. The implication of this is that technological development adaptation strategies and farm production adaptation strategies affected livelihood of smallholder vegetable farmers.

On the other hand, the null hypotheses H_{02} and H_{04} are accepted since the p -values were greater than 0.05. Perhaps the factors that affect decision to adopt adaptation strategies differ. This therefore implies that despite diversified adaptation strategies, the livelihood of smallholder vegetables farmers still remain vulnerable to adverse effects of climate variability since some adaptation strategies did not make a significant

contribution to livelihood of smallholder vegetable farmers. It can therefore be argued that, although progress has been made in managing the risks of climate variability, the adaptation strategies undertaken so far are insufficient to address the short and long-term effects of climate variability and to maintain livelihood of smallholder farmers. This situation highlights the need to upscale adoption of all adaptation strategies as a means to sustainable livelihood of smallholder farmers.

4.13 Chapter Summary

This chapter entailed data presentation, analysis, and interpretation based on the research objectives. The research findings were presented using tables and figures. The chapter has presented, analyzed and interpreted data on demographic characteristics, farming characteristics, climate variability adaptation strategies and livelihood. Results of correlation analysis and multiple regression analysis, have been presented, interpreted and discussed. Subsequently, β- values for each adaptation strategy from the model have been presented with the aim of ascertaining the contribution of each predictor variable to the regression model. Lastly, the chapter has presented, interpreted and discussed hypotheses testing results.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main purpose of this chapter is to summarize and conclude the study report. The chapter entails six distinct sections where summary of findings has been presented in the first section basing on research objectives, followed by limitations of the study in the second section. Later the chapter presents, conclusions of the study in the third section, followed by implications for policy and theory in the fourth section. The fifth section deals with recommendations of the study based on the conclusions and finally suggestions for further studies have been outlined in the sixth section.

5.2 Summary of Findings

Driven by the fact that adapting to climate variability is central to the livelihood of smallholder farmers in Kampala, the current study sought to establish the effect of technological development adaptation strategies, government support programs, farm production adaptation strategies and farm financial management adaptation strategies on livelihood of smallholder vegetable farmers in Kampala district.

5.2.1 Effect of Technological Development Adaptation Strategies on Livelihood of Smallholder Vegetable Farmers

The first objective was to establish the effect of technological adaptation strategies on livelihood of smallholder vegetable farmers. The study found that various adaptation technologies were used to curb the negative impact of climate variability. These included; using weather forecasts and climate information in planning vegetable farming activities, harvesting water for irrigation, changing soil conservation technologies, using water pans and planting a variety of crops (Table 4.13). It emerged from the study that

radio and television were the main sources of weather forecast and climate information (Table 4.14). The study found that other sources of weather forecast and climate information were mobile phones, neighbours and Newspapers. It also emerged from the study that farmers used both traditional and modern water harvesting techniques such as plastic water tanks to collect rain water from rooftops with the help of gutters. In addition, the study found that farmers altered traditional and innovative soil conservation practices in order to maintain soil productivity and thus improve livelihood. It was also revealed that use of water pans was common and these helped farmers to collect run-off ground water used to irrigate vegetable gardens. It emerged that vegetable farmers planted a variety of vegetables as an adaptation strategy so that that if some fail others survive. Pearson correlation coefficient showed that there was a strong positive relationship between technological development adaptation strategies ($r= 0.810$ and $p =0.000$) and livelihood of smallholder vegetable farmers (Table 4.30) while multiple linear regression analysis results depicted that there was a significant relationship between technological development adaptation strategies ($\beta_1=0.357$ and $p=0.000$) and livelihood of smallholder vegetable farmers (Table 4.35). Therefore, a unit increase in technological development adaptation strategies led to improvement in livelihood of smallholder vegetable farmers thus the null hypothesis **(Ho_1)** was rejected.

5.2.2 Effect of Government Agricultural Support Programs on Livelihood of Smallholder Vegetable Farmers.

The second objective was to determine the effect of government agricultural support on livelihood of smallholder vegetable farmers. The study found that very few respondents (8%) received government agricultural support (Table 4.15). The study found that most smallholder vegetable farmers (92%) did not receive government support towards vegetable farming. The study established that government agricultural support was

received in form of agricultural training, agricultural extension services, subsidized credit, agricultural inputs and market support (Table 4.16). The study found that farmers received training in smart agriculture technologies like water harvesting, and in agri-business at Kyanja agricultural resource centre and during agriculture exhibitions such as 'harvest Money Expo' to build their adaptive capacity. It emerged from the study that farmers accessed extension services through district extension officers in form of adaptation information, agriculture advise, technical support, advice and supply of inputs. It also emerged that farmers who had collateral and those who belonged to farmers' groups accessed government subsidized credit from government aided schemes and microfinance institutions. It also emerged that farmers received agricultural inputs such as fertilizers, high quality seeds, crop protection chemicals and seedlings to maximize crop production.

Further, the study found that market support was given to farmers in form of market price information to enable smallholder farmers make appropriate decisions. Pearson correlation coefficient showed that there was a weak positive relationship between government agricultural support ($r = 0.423$ and $p = 0.000$) and livelihood of smallholder vegetable farmers (Table 4.30) while multiple linear regression analysis results depicted that there was no significant relationship between government support strategies ($\beta_2 = -0.037$ and $p = 0.351$) and livelihood of smallholder vegetable farmers (Table 4.35). Therefore, a unit increase in government support strategies does not lead to improvement in livelihood of smallholder vegetable farmers, thus, the null hypothesis was accepted.

5.2.3 Effect of Farm Level Production Adaptation Strategies on Livelihood of Smallholder Vegetable Farmers

The third objective of this study was to assess the effect of farm level production adaptation strategies on livelihood of smallholder vegetable farmers. The study found that smallholder vegetable farmers applied a wide range of climate variability adaptation strategies at the farm level in an effort to reduce impact of extreme weather events (Table 4.17). Farm production adaptation strategies employed included; mulching, crop rotation, crop boosters, mixed cropping, changing planting & harvesting, planting drought resistant varieties, planting trees, selling household assets, planting multiple vegetable varieties, and burying crop residues. It emerged from the study that household assets sold by farmers are crop harvests, livestock like pigs and goats. It was established that planting high yield water sensitive crops was the most applied farm production adaptation strategy. Pearson correlation coefficient results indicated that there was strong positive relationship between farm production strategies ($r=0.848$ and $p=0.00$) and livelihood of smallholder vegetable farmers (Table 4.30) while multiple linear regression analysis results showed that there was a significant relationship between farm production adaptation strategies ($\beta_3=0.557$ and $p=0.000$) and livelihood of smallholder vegetable farmers (Table 4.35). Therefore, a unit increase in farm production adaptation strategies led to improvement in livelihood of smallholder vegetable farmers thus, the null hypothesis was rejected.

5.2.4 Effect of Farm Financial Management Adaptation Strategies on Livelihood of Smallholder Vegetable Farmers

The last objective was to establish the effect of farm financial management adaptation strategies on livelihood of smallholder vegetable farmers. From the findings, farm financial management adaptation strategies were used by smallholder vegetable

farmers to minimize negative impacts of climate variability. These included; budgeting, paying loan on time, borrowing money from financial institutions, insuring vegetable farm, saving and engaging in other economic activities (Table 4.18). The study established that insuring vegetable farms was not very popular among smallholder vegetable farmers. It also emerged that Covid-19 and environmental shocks rendered financial management skills and training important to farmers more than ever before due to the financial challenges they pose to farmers' financial standing. Further, it emerged from the study that smallholder farmers engaged in other economic activities such as teaching, hawking, hairdressing, small business, market vending, cleaning companies, catering, secretarial work, shop keeping, shoe vending. Pearson correlation coefficient showed that there was a strong positive relationship between farm financial management strategies ($r = 0.773$ and $p = 0.000$) and livelihood of smallholder vegetable farmers (Table 4.30) while multiple linear regression analysis results indicated that there was no significant relationship between farm financial management adaptation strategies ($\beta_2 = 0.082$ and $p = 0.263$) and livelihood of smallholder vegetable farmers (Table 4.35). Therefore, a unit increase in farm financial management adaptation strategies did not lead to improvement in livelihood of smallholder vegetable farmers thus, the null hypothesis was accepted.

5.3 Limitations of the Study

To begin with, the researcher had limited physical access to documents pertaining to urban farming from the directorate of gender, community services and production. To ensure that the researcher got all the requisite information, the researcher accessed online journals and eBooks.

Secondly, the study was limited by few recent studies in the area of urban agriculture adaptation in Uganda. To fill the gap the study reviewed literature on climate change and variability adaptations and livelihood in rural areas as well as urban areas outside Uganda.

Further, there was limited access to respondents as most of them could not be located at agreed time and location as they were engaged in other off farm income generation activities. The researcher exercised patience and in some other cases rescheduled the meetings to fit into the schedule of respondents.

Attempt to visit various offices to acquire study materials and access NAADS and KCCA officials was limited by the Covid -19 pandemic. To get the relevant information from the officials, the researcher requested officials to send relevant materials on climate change and variability via her email address. The researcher also conducted some interviews via zoom.

5.4 Conclusion

From the study findings it is concluded that smallholder vegetable farmers applied a number of climate variability adaptation strategies to minimize impact of climate variability on their livelihood.

Effect of Technological Development Adaptation Strategies and Livelihood of Smallholder Vegetable Farmers

The study concluded that technological development adaptation strategies included; using weather forecast and climate information, harvesting rain water, changing soil conservation technologies, using water pans and planting a variety of vegetables. Secondly, vegetable farmers relied on various sources of weather forecast and climate

information which they used in planning their activities. The study concluded that technological development adaptation strategies had a significant effect on livelihood of smallholder vegetable farmers. Therefore, for every increase in adoption of technological development strategies there was a corresponding improvement in livelihood of smallholder vegetable farmers.

Effect of Government Agricultural Support Adaptation Strategies and Livelihood of Smallholder Vegetable Farmers

From the study it is concluded that, government support programs as adaptation strategies were very limited to farmers. Thus, smallholder vegetable farming was largely self-supported. A few farmers received the support in form of agricultural training; agricultural extension services inputs, market support, agricultural training and subsidized credit. The study concluded that government agricultural support strategies had no significant effect on livelihood of smallholder vegetable farmers. Therefore, for every increase in government support adaptation strategies there was no corresponding improvement in livelihood of smallholder vegetable farmers.

Effect of Farm Production Adaptation Strategies and Livelihood of Smallholder Vegetable farmers

The study concluded that at the farm level vegetable farmers practiced mulching, crop rotation, crop boosters, mixed cropping, changing planting & harvesting, planting drought resistant varieties, planting trees, selling household assets, planting multiple vegetable varieties, and burying crop residues. Further, the study concluded that, farm production adaptation strategies had a significant effect on livelihood of smallholder vegetable farmers. Therefore, for every increase in farm production adaptation

strategies there was a corresponding improvement in livelihood of smallholder vegetable farmers.

Effect of Farm Financial Management Adaptation Strategies on Livelihood of Smallholder Vegetable farmers

The study concluded that vegetable farmers employed farm budgeting, paying loan on time, borrowing money from financial institutions, insuring vegetable farm, saving a percentage of income and engaging in other economic activities. Insuring vegetable farm was not very popular among vegetable farmers. Covid -19 posed serious financial challenges to farmers thus financial management skills became very important in the adaptation struggle. The study concluded that there was no significant effect of farm financial management adaptation strategies on livelihood of smallholder vegetable farmers. Therefore, for every increase in farm financial management adaptation strategies there was no corresponding improvement in livelihood of smallholder vegetable farmers.

The general conclusion of the study is that while some climate variability adaptation strategies enhanced livelihood others did not. Adaptation strategies are interrelated in that successful application of one category of adaptation strategies depends on availability, accessibility and affordability of other adaptation strategies. Thus, no single strategy is sufficient on its own; all should be part of a broader agriculture adaptation framework. Smallholder farmers are committed to adapt to climate variability and improve livelihood however they face are constrained by a number of constraints.

5.5 Implications of the Study

The findings of the study have broader policy and theoretical implications.

5.5.1 Policy Implications

The findings elaborate and confirm the importance of adopting climate variability adaptation strategies to enhance livelihood of respondents. Such information is important to any stakeholder in the study area. By focusing closely on each adaptation strategy, stakeholders in urban farming and climate adaptation are able to plan the advancement of adaptation policies and programs in the district.

The findings also have implications on roles played by agriculture extension service providers. By integrating climate variability adaptation perspective, agriculture extension workers are able to re-examine and re-evaluate extension programs extended to farmers in the district. For instance, public and private extension workers have marked influence on the choice of adaptation strategies farmers make.

The findings further offer empirical evidence on climate adaptation challenges in Kampala district including technological, financial and resource related adaptation constraints. The motivation to adopt adaptation strategies surrounds effects of adaptation strategies on livelihood of vegetable farmers in Kampala district Uganda. In the researcher's opinion, effective climate adaptation depends on availability, accessibility and affordability of the all adaptation strategies.

5.5.2 Theoretical Implications

The study findings and analysis confirm the Sustainable Livelihood Approach, since the findings clearly show that various factors constrain while others enhance livelihood opportunities of the poor and that no single factor is sufficient on its own to improve the poor people's livelihood. The sustainable livelihood approach provides an analytical structure that facilitates a broad and systematic understanding of various factors that constrain or enhance livelihood opportunities and shows how factors relate to each other.

The findings presented in chapter four highlight the relevance of action theory of adaptation, since it's clear that adaptation actions require actors, an intention and resources to address the goal. The intention of smallholder adaptation is to reduce negative impacts of extreme climatic events such as floods, droughts and wind storms on livelihood. Further, the findings also clearly confirm that climate adaptation efforts are provoked by a stimulus and that receptors have to take actions to avert risk.

The findings in chapter four lend support to the diffusion of innovations theory. The findings clearly show how adaptation strategies as innovations are diffused among farmers. Study findings indicate that some adaptations were highly adopted compared to others. For instance, findings showed that crop insurance was not very popular among farmers. Therefore, the choice of adaptation strategies according to the study respondents seems to depend on relative advantage, compatibility with existing values and practices, simplicity and ease of use, trialiblility and observation of results from innovations

The study is consistent with sustainable livelihood approach vulnerability context of the poor. The findings clearly show that the poor are exposed to climate change and

variability shocks such as floods, droughts and wind storms which increase their vulnerability to poverty. Further, the findings of the study lend support to the Sustainable Livelihood approach's transforming structures and processes which influence livelihood outcomes. For instance, findings show that government was too inadequate to influence livelihood of smallholder farmers in Kampala district.

5.6 Recommendations

From the study findings and conclusion, the following recommendations are made.

1. Therefore, the government of Uganda should continue and strengthen support towards urban farming and climate variability adaptation by increasing budgetary allocation to Kampala district aimed at financing agricultural support programs. The government should encourage consolidation of public-private partnerships, non-governmental organization engagement and mobilization of finances from the Adaptation Fund which helps developing countries build resilience and adaptation to climate change.
2. There is need for the Ministry of Finance, Planning and Economic Development to encourage microfinance institutions to incorporate a pro-poor perspective in their operations within Kampala district with an aim of reaching out to even the society's most poor.
3. Kampala Capital City Authority should through a census establish a data base of all smallholder farmers, the area of land they hold, resources they own, and their farming requirements. This will help to determine the number of farmers and consequently amount of support services required.
4. In addition, NAADS should build the capacity of extension officers through training on climate variability adaptation strategies which will enable them to

supervise farming activities, disseminate correct and accurate information to the farmers for better adaptation and improvement of well-being of farmers.

5. To deal with limited use of crop insurance, NAADS and KCCA need to carryout mass sensitization on crop insurance with an aim of indemnifying urban vegetable farmers against the loss of crop due to climate variability extreme events like drought, storms and floods. This can take the form of sensitization programs, campaigns, seminars, media platforms, extension services and campaigns on crop insurance coverage and accompanying benefits.
6. In terms of insufficient financial management skills, the department of gender, community service and production needs to strengthen all farm financial management adaptations. It is important to train vegetable farmers in farm financial management techniques like budgeting, book keeping, saving and crop insurance. This will equip farmers with adequate financial management knowledge and skills at all times.
7. The study recommends that KCCA promotes adaptation strategies as a package comprising of technological, government support, farm production and financial management adaptation strategies rather than promoting piecemeal measures. This will help save on time, finances and will foster goal achievement both at the household and district levels.
8. The study recommends that smallholder vegetable farmers in Kampala district form farmers' adaptation groups. This will help strengthen their relationships with one another, improve climate adaptation knowledge, re-think their adaptation mechanisms and thus help traverse climate variability adaptation through helping each other.

5.7 Suggestions for Further Studies

a) A study should be conducted on smallholder adaptation in other urban areas in other districts. This will help other urban areas with findings from the present study.

b) A study should be carried out to explore climate variability adaptation strategies and livelihood of smallholder urban livestock farmers. This will enable a comparison between crop and livestock farming adaptation strategies and livelihood of farmers.

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APPENDICES

Appendix I: Rotated Component Matrix for Technological Development adaptation Strategies

	Component	
	1	2
Weather forecast and climate information	.811	
Water harvesting for irrigation	.810	
changing soil conservation technologies	.695	
Water pans for irrigation	.694	
A variety of vegetables		.957

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Source: Author's Compilation (2021)

Appendix II: Rotated Component Matrix for Government Agricultural Support

	Component	
	1	2
Agricultural training	.863	
Agricultural extension services	.830	
Subsidized credit		.768
Agricultural inputs		.697
Market support		.562

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Source: Author's Compilation (2021)

Appendix III: Rotated Component Matrix for Farm Production Strategies

	Component			
	1	2	3	4
Mulching	.944			
Using crop rotation	.944			
Using crop boosters	.627			
Mixed cropping	.571			
Changing planting & harvesting dates		.889		
Planting high yield water sensitive crops		.861		
Planting drought resistant varieties		.642		
Planting trees			.787	
Selling household assets			.784	
Planting multiple vegetable varieties				.856
Burying crop residues				.672

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Source: Author's Compilation (2021)

Appendix IV: Rotated Component Matrix for Financial Management Adaptation Strategies

	Component	
	1	2
Farm budgeting	.800	
Paying loans on time	.744	
Borrowing money from financial institutions	.714	
Insuring vegetable farm	.687	
Saving a percentage income generated from vegetable farming		.813
Engaging in other economic activities		.804

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Source: Author's Compilation (2021)

Appendix V: Rotated Component Matrix for Livelihood of Smallholder Vegetable Farmers

	Component			
	1	2	3	4
Increased income source diversification	.767			
Increased household net income	.760			
Increased financial Independence	.746			
Increased sustainable use of NR base	.669			
Increased asset ownership	.581			
Reduced vulnerability		.820		
Increased structures & institutions		.724		
Increased welfare		.671		
Increased participation in decision making		.530		
Increased livelihood policies			.848	
Increased food stability			.777	
Increased food productivity			.514	
Increased knowledge application				.814
Household access to food				.757

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Source: Author's Compilation (2021)

Appendix VI: Respondents Informed Consent Form

Name: Nassiwa Florence

Phone No. +254 -703103201/+256-701 668065

E-mail Address: flokip@yahoo.com

Study Title: Climate Variability Adaptation Strategies and Livelihood of Smallholder Vegetable Farmers in Kampala District Uganda.

You are invited to participate in a research study investigating the results of using climate variability adaptation strategies in your vegetable farm. All information that you provide to us will be remain strictly confidential. If you volunteer to participate in this study kindly note that you are free to withdraw at any time without giving any reason and without there being a penalty. In addition if you do not wish to answer any specific questions, you are free to decline. If you would like to talk to someone other than the researcher (s) about; (1) concerns regarding this study, (2) research participant rights, (3) research-related injuries, or (4) other human subjects' issues, please contact:

Assoc. Prof. Neema Stella, The Chair, Makerere School of Social Sciences, Research Ethics Committee; Telephone: +256- 772 457576, E-mail: sheisim@yahoo.com , And, Dr. Ndemere Peter The Executive Secretary , The Uganda National Council of Science and Technology, Kimera Road. Ntinda P. O. Box 6884 Kampala, Uganda; Telephone: (256) 414 705500, Email: info@uncst.go.ug

Statement of Consent

I have read or have read to me the above study and have had an opportunity to ask questions which have been answered to my satisfaction. I agree voluntarily to participate in the study as described.

Name of participant: ---------- I am ----------years of age.

Signature or thumbprint/mark of participant----------Date: ----------

Name of Person obtaining consent: ----------

Signature of person obtaining consent: ----------Date: ----------

Witness of person in case person is Illiterate:

Name of Witness: ----------

Signature or thumbprint/mark of witness: ----------Date: ----------

Source: Author's Compilation (2021)

Appendix VII: Questionnaire for Smallholder Vegetable Farmers in Kampala District Uganda

Please complete the questionnaire honestly by ticking or writing the most appropriate answer in the spaces provided. Please tick (√) or fill in the blanks as appropriate and respond to all items.

Contact:……Division:……Parish:……..

Section A: Background Information

1. What is your gender? Male [ ] Female [ ]
2. What is your marital status? Married [ ] Single [ ] Widow/widower [ ] Separated [ ] Divorced [ ]
3. Your age group; 18-25 [ ] 25-30 [ ] 30-35 [ ] 35-40 [ ] 40 years and above [ ]
4. Your Education Level; Never went to school [ ] Primary school [ ] Secondary [ ] Tertiary [ ] University [ ]
5. Household head Yes [ ] No [ ]
6. Income 10000-100000 [ ] 110000-200000 [ ] 210000-300000 [ ] 310000-400000 [ ] 410000-500000 [ ] 510000 and above [ ]
7. What is your occupation?.....

Section B: Smallholder Vegetable Farming Characteristics

8. Which type of urban farming is practiced? Vegetable Both vegetable and livestock
9. What type of vegetables did you grow in 2020?

Fruit Vegetables [ ] Leaf Vegetables [ ] Root vegetables [ ]

10. How long do vegetables take to mature?

Less than one Month [ ] 1-3 Months [ ] 4-7 Months [ ]

11. Where do you grow vegetables? Homestead (On-plot) [ ]

Land away from the residence(off-plot) [ ]

12. How long have you grown Vegetables?

1-5years [ ] 6-10years [ ] 11-15years [ ] 16-20years [ ] 20 years and above [ ]

Section C: Climate Variability

13. The following statements are about climate variability. Kindly indicate your level of agreement or disagreement with each of the statements using the following scale: where **1** = Strongly Disagree (**SD**); **2** = Disagree **(D); 3** = Neutral **(N); 4** = Agree (**A);** and **5** = Strongly Agree **(SA)**

No	Statements	SD	D	N	A	SA
	There were changes in rainfall pattern in 2020					
	There were changes in temperature in 2020					
	There were changes in wind in 2020					

14. Did you use climate variability adaption strategies in 2020?

Yes [ ] No [ ]

Section D: Technological Development Adaptation Strategies

15. The following statements are about technological development adaptation strategies. Kindly indicate your level of agreement or disagreement with each of the statements using the following scale: where **1** = Strongly Disagree (**SD**); **2** = Disagree **(D); 3** = Neutral **(N); 4** = Agree (**A);** and **5** = Strongly Agree **(SA)**

No.	Statements	SD	D	N	A	SA
1	I relied on weather forecast and climate information to plan vegetable farming activities					
2	I practiced water harvesting for irrigating vegetable gardens					
3	I changed soil conservation technologies					
4	I used water pans to irrigate crops					
5	I planted a variety of vegetables					
	Sources of weather forecast and climate information					
6	I accessed weather forecast and climate information from television					
7	I accessed weather forecast and climate information from radio					
8	I accessed weather forecast and climate information via mobile phone					
9	Neighbours provided weather forecast and climate information					
10	I accessed weather forecast and climate information from Newspapers					

Section E: Government Agricultural Support programs Strategy

16. Did you receive government agriculture support towards vegetable farming in the year 2020? Yes [ ] No [ ]

If **yes** what form of government agriculture support did you receive? (Tick the right answer)

No.	Statements	Yes	No
1	I received government agricultural training		
2	I received government agricultural extension services		
3	I received subsidized credit from the government		
4	I received agricultural inputs		
5	I received government market support		

Section F: Farm Production Adaptation Strategies

17. The following statements about farm production adaptation strategies. Kindly indicate your level of agreement or disagreement with each of the statements using the following scale: where **1** = Strongly Disagree (**SD**); **2** = Disagree **(D); 3** = Neutral **(N); 4** = Agree (**A);** and **5** = Strongly Agree **(SA)**

No.	**Statements**	**SD**	**D**	**N**	**A**	**SA**
1	I practiced mulching					
2	I practiced crop rotation on my vegetable garden					
3	I used crop boosters					
4	I practiced mixed cropping					
5	I changed planting and harvesting timing					
6	I planted high yield water sensitive vegetables					
7	I planted drought resistant varieties					
8	I planted trees in my vegetable garden					
9	I sold household assets to purchase farm inputs					
10	I planted multiple vegetable varieties					
11	I buried residues to replenish soil fertility					

Section G: Financial Management Adaptation Strategies

18. The following statements are about financial management adaptation strategies. Kindly indicate your level of agreement or disagreement with each of the statements using the following scale: where 1 = Strongly Disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); and 5 = Strongly Agree (SA)

No.	Statements	SD	D	N	A	SA
1	I practiced farm budgeting					
2	I paid loans on time					
3	I borrowed money from financial institutions					
4	I insured vegetables crops					
5	I saved a percentage of my income generated from vegetable farming					
6	I engaged in other economic activities					

Section H: Livelihood of Smallholder Vegetable Farmers

19. The following statements are about livelihood of smallholder vegetable farmers. Kindly indicate your level of agreement or disagreement with each of the statements using the following scale: where 1 = Strongly Disagree (SD); 2 = Disagree (D); 3 = Neutral (N); 4 = Agree (A); and 5 = Strongly Agree (SA)

No	Statements	SD	D	N	A	SA
	Household Income					
1	Adaptation strategies increased income source diversification					
2	Adaptation strategies increased household net income					
3	Adaptation strategies increased financial independence					

4	Adaptation strategies increased household welfare					
	Household Food Security					
5	Adaptation increased household food productivity					
6	Adaptation increased household access to food					
7	Adaptation increased household food stability					
	Household Assets					
8	Adaptation strategies increased asset ownership					
9	I used natural resource base more sustainably					
	Knowledge Acquisition &Application					
10	Adaptation strategies increased knowledge application					
11	Adaptation strategies increased my decision making					
	Livelihood Structures & Policies					
12	There was an increase in livelihood structures and institutions					
13	There was an increase in livelihood policies					
14	Adaptation reduced vulnerability to hazards					

End

Thank You

Source: Author's Compilation (2021)

Appendix VIII: Key Informant Interview Schedule

1. Does age influence farmers participation in urban vegetable farming?
2. What is your perception about climate variability in Kampala district?
3. What are the forms of urban farming in the district?
4. Is climate change adaptation new to farmers in the district?
5. What are the sources of weather forecast and climate information in the district?
6. What is the role of the Meteorological department in farmer's climate change adaptation?
7. How is irrigation practiced by farmers?
8. Which soil conservation techniques do farmers employ?
9. What forms of training do you offer to farmers?
10. What role does KCCA play in training farmers in the district?
11. What are the benefits of extension services to farmers?
12. Does the government provide subsidized credit to farmers?
13. Does KCC provide credit to farmers?
14. What challenges do farmers encounter in adapting to changing climate?
15. What steps have you taken to provide market support to farmers?
16. What is your opinion on selling of household assets as a way of responding to climate variability?
17. What reasons compel farmers to plant drought resistant crops?
18. What is the significance of farm budgeting?
19. Apart from vegetable farming which other economic activities do farmers engage in?
20. Explain how adaptation to climate variability leads to financial independence

21. Explain how adaptation to climate variability can lead to acquisition of household assets
22. What is the role of adaptation in vulnerability reduction
23. Describe the role of institutions in ensuring sustainable livelihoods
24. What is your opinion on the relationship between adaptation and farmers welfare
25. Explain the role of adaptation in enhancing farmers decision making capacity
26. Which livelihood activities are being implemented in Kampala district in line with livelihood policies?
27. How does application of adaptation strategies increase knowledge application?

Source: Author's Compilation (2021)

Appendix IX: Observation Guide

1. Forms of urban farming by smallholder farmers
2. Types of vegetables grown
3. Location of vegetable gardens
4. Water conservation techniques used by farmers
5. Kyanja agricultural resource centre
6. Adaptation strategies employed by farmers

Source: Author's Compilation (2021)

Appendix X: Moi University Introduction Letter

MOI UNIVERSITY
(ISO 9001:2015 CERTIFIED INSTITUTION)
SCHOOL OF ARTS & SOCIAL SCIENCES

Tel: (053) 43093
(053) 43620 Ext 2515
Fax: (053) 43047
E-mail: deanarts@mu.ac.ke

P.O Box 3900
ELDORET
KENYA

22nd November, 2019

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: FLORENCE NASSIWA – SHRD/PHDDD/07/15

This is to certify that the above named is a bonafide student at Moi University, School of Arts and Social Sciences. She is a Doctor of Philosophy student in Development Studies in her second year of study.

She has completed her coursework component and proposal and has now embarked on Thesis writing.

Her Thesis is entitled: **"Effect of Smallholder Farmers Climate Variability Coping and Adaptation Strategies on Vegetable Yields in Kampala District, Uganda".**

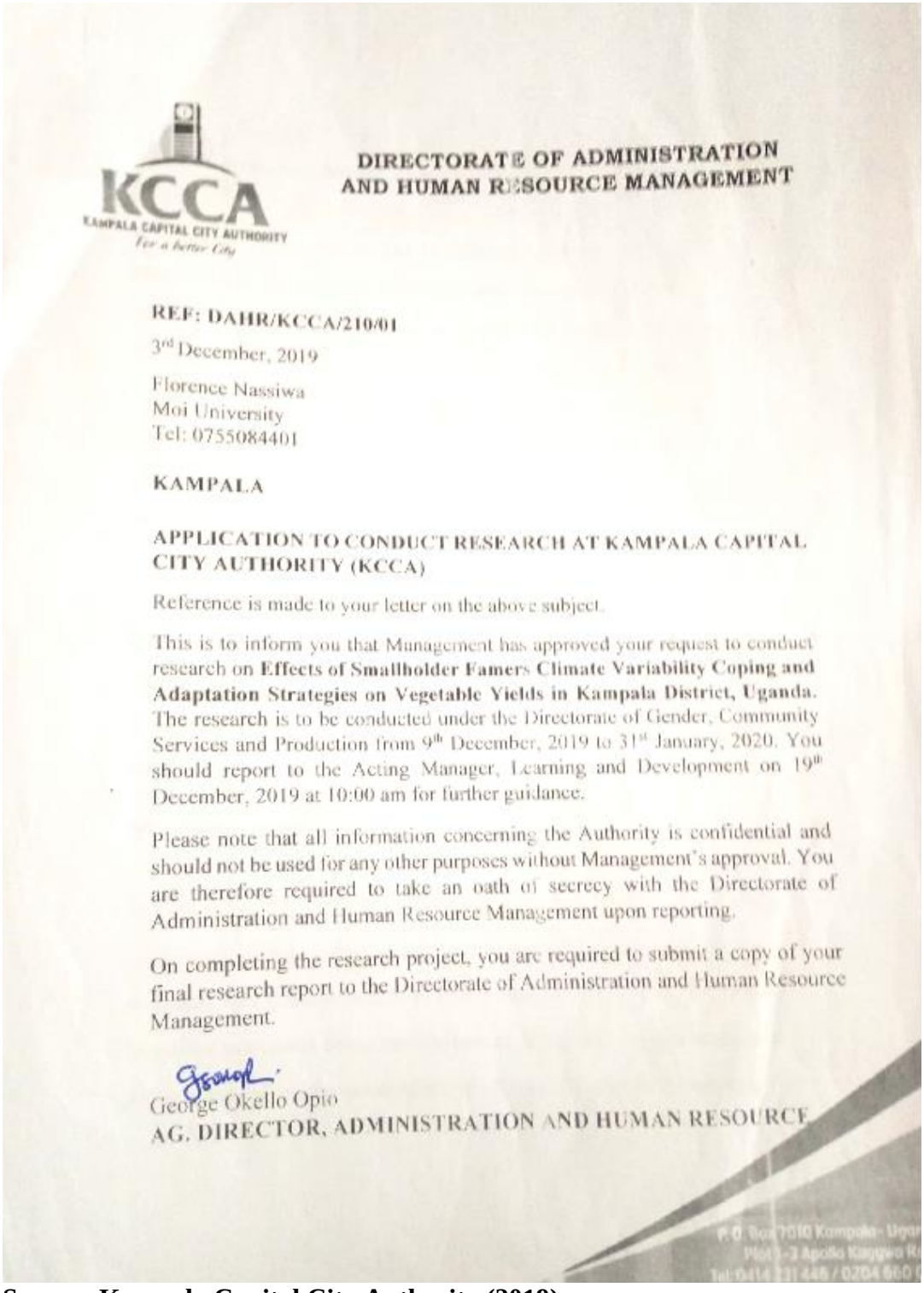
Any assistance accorded to her will be appreciated.

DEAN
SCHOOL OF ARTS & SOCIAL SCIENCES
MOI UNIVERSITY

PROF. MARY WAMOMI
ASSOCIATE DEAN, SCHOOL OF ARTS AND SOCIAL SCIENCES

Source: Moi University, School of Arts and Social Sciences (2019)

Appendix XI: KCCA Authorization Letter



KCCA
KAMPALA CAPITAL CITY AUTHORITY
For a better City

DIRECTORATE OF ADMINISTRATION AND HUMAN RESOURCE MANAGEMENT

REF: DAHR/KCCA/210401

3rd December, 2019

Florence Nassiwa
Moi University
Tel: 0755084401

KAMPALA

APPLICATION TO CONDUCT RESEARCH AT KAMPALA CAPITAL CITY AUTHORITY (KCCA)

Reference is made to your letter on the above subject.

This is to inform you that Management has approved your request to conduct research on **Effects of Smallholder Famers Climate Variability Coping and Adaptation Strategies on Vegetable Yields in Kampala District, Uganda.** The research is to be conducted under the Directorate of Gender, Community Services and Production from 9th December, 2019 to 31st January, 2020. You should report to the Acting Manager, Learning and Development on 19th December, 2019 at 10:00 am for further guidance.

Please note that all information concerning the Authority is confidential and should not be used for any other purposes without Management's approval. You are therefore required to take an oath of secrecy with the Directorate of Administration and Human Resource Management upon reporting.

On completing the research project, you are required to submit a copy of your final research report to the Directorate of Administration and Human Resource Management.

George Okello Opio
AG. DIRECTOR, ADMINISTRATION AND HUMAN RESOURCE

Source: Kampala Capital City Authority (2019)

Appendix XII: UNCST Research Permit

Uganda National Council for Science and Technology

(Established by Act of Parliament of the Republic of Uganda)

Our Ref: SS649ES **18 December 2020**

Florence Nassiwa
Kampala Capital City Authority
Kampala

Re: Research Approval: **Effect of climate variability adaptation strategies on livelihood of smallholder vegetable farmers in Kampala District Uganda**

I am pleased to inform you that on **18/12/2020**, the Uganda National Council for Science and Technology (UNCST) approved the above referenced research project. The Approval of the research project is for the period of **18/12/2020** to **18/12/2021**.

Your research registration number with the UNCST is **SS649ES**. Please, cite this number in all your future correspondences with UNCST in respect of the above research project. As the Principal Investigator of the research project, you are responsible for fulfilling the following requirements of approval:

1. Keeping all co-investigators informed of the status of the research.
2. Submitting all changes, amendments, and addenda to the research protocol or the consent form (where applicable) to the designated Research Ethics Committee (REC) or Lead Agency for re-review and approval **prior** to the activation of the changes. UNCST must be notified of the approved changes within five working days.
3. For clinical trials, all serious adverse events must be reported promptly to the designated local REC for review with copies to the National Drug Authority and a notification to the UNCST.
4. Unanticipated problems involving risks to research participants or other must be reported promptly to the UNCST. New information that becomes available which could change the risk/benefit ratio must be submitted promptly for UNCST notification after review by the REC.
5. Only approved study procedures are to be implemented. The UNCST may conduct impromptu audits of all study records.
6. An annual progress report and approval letter of continuation from the REC must be submitted electronically to UNCST. Failure to do so may result in termination of the research project.

Please note that this approval includes all study related tools submitted as part of the application as shown below:

No.	Document Title	Language	Version Number	Version Date
1	consent form	English	2	30 September 2020
2	Risk management plan	English	2	30 September 2020
3	Research questionnaire	English	2	30 September 2020
4	Project Proposal	English	2	
5	Approval Letter	English	2	2020-09-30
6	Administrative Clearance	English	2	2020-09-30

Yours sincerely,

Hellen Opolot
For: Executive Secretary
UGANDA NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

LOCATION/CORRESPONDENCE

Plot 6 Kimera Road, Ntinda
P.O. Box 6884
KAMPALA, UGANDA

COMMUNICATION

TEL: (256) 414 705500
FAX: (256) 414-234579
EMAIL: info@uncst.go.ug
WEBSITE: http://www.uncst.go.ug

Source: Uganda National Council for Science &Technology (2021)

Appendix XIII: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 289949

Date of Issue: 10/January/2022

RESEARCH LICENSE

This is to Certify that Ms.. Florence Nassiwa of Moi University, has been licensed to conduct research in Uasin-Gishu on the topic: CLIMATE VARIABILITY ADAPTATION STRATEGIES AND LIVELIHOOD OF SMALLHOLDER VEGETABLE FARMERS IN KAMPALA DISTRICT UGANDA for the period ending : 10/January/2023.

License No: NACOSTI/P/22/13586

289949

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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Source: National Commission for Science, Technology & Innovation (2022)