FACTORS INFLUENCING THE ADOPTION OF GREENHOUSE FARMING BY SMALLHOLDERS IN CENTRAL IMENTI SUBCOUNTY IN MERU COUNTY.

MUGAMBI DORCAS MUGURE

C50/5549/2017

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ARTS IN ENVIRONMENTAL PLANNING AND MANAGEMENT IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES OF THE UNIVERSITY OF NAIROBI

DECLARATION

This project is my original work and has not been submitted for award of a degree in any other university.

Candidates name:

Dorcas Mugure Mugambi (C50/5549/2017)

26/11/2020

Signature Date

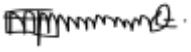
Supervisors: This project has been submitted with our approval as university supervisors.

Dr. Boniface Wambua
Department of geography and environmental studies
University of Nairobi.

…….. 26/11/2020

Signature Date

Dr. Martin Marani
Department of Geography and environmental studies
University of Nairobi.



26/11/2020

Signature Date

DEDICATION

To my late Dad Julius Mugambi.

To my husband Mutuma Nkanata and kids Irvin, Ivy and Ivan.

ACKNOWLEDGEMENT

My sincere gratitude goes to everyone from the University of Nairobi, NACOSTI and Meru County for their generous support, guidance, interaction and encouragement during my studies. Without the undeserved help, valuable guidance, patience and commitment of my supervisors, this study would not be achieved. Their efforts will not be forgotten too soon. My sincere and heartfelt thanks go to Dr. Boniface Wambua and Dr. Martin Marani.

My special thanks and acknowledgement goes to all the Lecturers in the department of Geography and environmental studies for their guidance and input during my coursework and proposal development. Many thanks go to all other individuals and organizations who directly or indirectly contributed to the success of this study.

To my classmates' class 2017 at university of Nairobi who offered teamwork and gave the needed help and moral support during the entire period. From the bottom of my heart, I thank you all.

I remain indebted to my friends and colleagues at KEPHIS and my family members for their encouragement, understanding, support and daily prayers.

This study may not exactly match your expectations and I wish to carry the cross: the flaws and deficiencies solely remain mine.

LIST OF ABBREVIATIONS AND ACRONYMS

BFA: Big four Agenda

EU: European Union

FAO: Food and Agriculture organization

GDP: Gross domestic product

GOK: Government of Kenya

GHF: Greenhouse Farming

HCD: Horticulture Crops Directorate

KHDP: Kenya Horticultural Development Programme

KEPHIS: Kenya Plant Health Inspectorate Service.

KNBS: Kenya National Bureau of statistics

KALRO: Kenya Agriculture livestock research organization

MOA Ministry of Agriculture

NALEP: National Agriculture and Livestock Programme

SPSS: Statistical package for Social Sciences

SDGs: Sustainable development goals.

SRA: Strategy for revitalizing Agriculture

SHFs: Small holder farmers

SACCOs: Savings and Credit Co-operatives

USAID: United States Agency for international development

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

ABSTRACT

The role of technology in agriculture production has continued to grow in importance over time. One method which has been proposed to address continued food production throughout the year and to meet the growing food demand is adoption of greenhouse farming more so by the small holder farmers who do it for own consumption and generation of income from the sale of surplus produce. Despite the known benefits of greenhouse farming technology, only a few small holder farmers have adopted it and most quit after a short time citing some constraints which serve as their major setback. This study therefore, aimed at assessing the factors influencing the adoption of greenhouse farming by small holder farmers in Central Imenti Sub County in Meru County. This study was guided by three objectives: to establish the extent of adoption of greenhouse farming by the small holder farmers in Central Imenti, to identify the factors influencing the adoption greenhouse farming by smallholders in Central Imenti sub county, and to assess the approaches optimized by the small holder farmers in Central Imenti to overcome the constraints to adoption of greenhouse farming. The study adopted descriptive survey research design having sampled 380 respondents by use of Stratified random and systematic sampling. Primary data was collected by use of scheduled interviews, questionnaires, observation and photography while secondary data was collected by reviewing ministry of agriculture and county reports Descriptive and inferential analysis were used in analyzing quantitative data and content analysis for the qualitative data. The presentation of the data focused on tables, frequencies, mean, percentages, pie charts, bar graphs and photographs. The study revealed that the level of adoption of greenhouse farming by small holders in Central Imenti Sub County was low at 42% compared to other counties. The study revealed that financial support which addresses the cost of greenhouse, availability of resources (land, water, labour), Technical experts support and the farmer's attributes like monthly income Level, knowledge, skills and experience with the technology influenced the adoption of greenhouse farming by small holders in Central Imenti Sub County. The small holder farmers in Central Imenti Sub county optimized in group greenhouse farming, online marketing and crops diversification in order to overcome constraints like high costs, lack of land, farm labour, water and marketing of their produce. It was evident that Lack of sufficient small holder farmer support systems in terms of Credit, water and farm inputs remained a key constraint hindering greenhouse adoption. The study concluded that the adoption of greenhouse farming by small holders in Central Imenti was low compared to other counties. The high cost of greenhouse installation and maintenance was identified as the major limitation to the adoption off greenhouse farming by small holder farmers. The study recommended on awareness creation by the ministry of Agriculture through the Counties on the potential of greenhouse farming which could be done through seminars, workshops, trainings, farm demonstrations, and stakeholder forums. This was expected to enhance adoption of this advanced technology by small holder farmers and diversification in the crops being cultivated. The government ought to develop and implement policy guidelines which creates a friendly and supportive environment for small holder farmers to adopt and sustainable remain farming using this specialized technology. The policy guidelines need to factor proper market price regulation, water provision to the farms and enhanced access to credit and farm inputs by the small holder farmers thereby promoting their adoption of the technology. The study recommended to the small holder farmers on the need to use local materials to build improvised greenhouses thereby cutting on the initial cost of farming using greenhouses and to organize themselves into groups in order to access credit, extension service and to bargain for better prices for farm inputs and their produce.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

A greenhouse is an enclosed structure covered with a transparent material which admits natural light or a permanent structure heated artificially providing a modified environment for the growth of plants (Janick, 1986; Liu & Nyalala, 2002). Greenhouses absorb solar energy from the sun which is collected in form of light and electromagnetic wavelengths thereby warming up the soil, plants and other objects in the greenhouse[1]. The transparent covering material allows in heat from the sun or artificially generated heat but prevents most of it from escaping causing the temperature inside the greenhouse to be higher than the temperature outside making the plants to have more warmth, grow faster and healthier (Liu & Nyalala, 2002).

A farmer can grow for to five crops in a greenhouse throughout the year which is made possible by the controlled environment conditions favoring increased crop productivity, higher quality produce and integrated management and control of pests and diseases in the enclosed facility (Liu & Nyalala, 2002). Greenhouse farming technology guarantees on efficient use of inputs like seeds, fertilizers, water and crop protection products[2] (The organic farmer, 2011).

Some of the benefits of greenhouse farming are; early maturity of plants due to high temperatures, effective pest and disease control at reduced costs, reduced or no chemical residues since less or no crop protection products are used, high yields, reduced risks and uncertainties, weed control and all year round production[3] (The Organic Farmer, 2011). The popularity of greenhouses in Kenya as an attempt to avoid the risks associated with climate change in crop production has increased (The Organic Farmer, 2011). The aggressive campaign and promotion of greenhouses, by the companies constructing them capitalizes on the fact that farmers are desperate for profitability arising from farming yet most are completely inexperienced in this advanced technology (Kamau & Bamgarrtner, 2011).

[1] See[1] www.nafis.go.ke (accessed on 05/07/2018)

[2] See also[2] www.farmerstrend.co.ke (accessed on 03/08/2018)

[3] See also [3] www.kalro.org (accessed on 24/08/2018)

For a long time, the use of greenhouse faming was reserved for Kenya's large scale horticultural farmers as most of the small scale holders could not afford the cost[4]. However, Kenya Horticultural Development Programme (KHDP) and Kenya Agricultural and livestock Research organization (KALRO) have worked to make it possible for small scale farmers to adopt greenhouse farming, which allows crop production throughout the year while maximizing their yields using less farm space and pesticides[5].

Greenhouse farming technology started in temperate regions where winter conditions cannot allow out door crop production. Some of the benefits associated with this advanced technology which motivated its spread to the tropics include controlling the rate of evapotranspiration, better yield by quality and quantity, extended production per area, assurance on throughout the year production, protection of crops from thieves, rains and wind damage (Nyalala et al, 2005). The production of hybrid seeds for Solanaceous and Brassicas families, plant conservation and museum, raising of seedlings including grafted plantlets and mushroom production is made possible under a greenhouse.

Hydroponics (soil less culture), aeroponics, nutrient film techniques and raising micro propagated plant-lets which are some of the modern farming technologies are only possible under greenhouse[5]. Some of the crops that have been successfully grown in a greenhouse are; tomatoes, capsicum, spices, herbs, onions, cucumber, strawberry, water melon, brinjals, butternut, cabbages, black nightshade and cow peas (NALEP2, 2011).

Tomato is mostly grown by small scale farmers due to its comparative advantages while flowers are grown in greenhouses by large scale companies due to their commercial advantages. Other crops are only grown as part of the crop rotation plan for management of pests and disease control in as much as their economic performance may be lower (NALEP2, 2011). Greenhouse farming technology and irrigation farming is a solution for many farmers due to unpredictable weather caused by climate change[6]. People employed in other sectors are

[4] *See also[4] for example, a greenhouse measuring 100 metres by 25 metres would cost about KSh34M (US$387,000) although this cost can typically be recovered from two years of production (Meru County, 2014)*

[5] *See also[5] for example, a greenhouse measuring 100 metres by 25 metres would cost about KSh34M (US$387,000) although this cost can typically be recovered from two years of production (Meru County, 2014).*

[6] *See [6]www.farmbizafrica.com (accessed on 05/07/2018)*

equally investing in small greenhouses where they grow vegetables for home consumption or extra income (The organic farmer, 2011).

According to FAO greenhouse farming is one way to increase Food production and feed increasing populations in developing countries. However, potential greenhouse farmers in countries like Kenya lack that information that could help them make decisions to venture into greenhouse farm enterprises (The organic farmer, 2011). Most farmers in the developing world strive to increase farm production without considerations of sustainability of soils and other natural resources that support agriculture (Ibid). Consequently, soils have been depleted and unit production has continued to decline posing an increasingly greater risk to future food security (Ibid). Adoption of greenhouse farming offers promising opportunities for improved efficiency in the use of water, land and even labor while giving the farmer greater independence and control over weather (The organic farmer, 2011).

Through widespread adoption of greenhouse farming, the farmer can also contribute significantly to addressing SDGs like putting an end to poverty, alleviating hunger, addressing climate change, and sustainably use the land and water resources as well as achievement of national development strategies such as Vision 2030, Strategy for Revitalizing Agriculture (SRA), and the Big Four Agenda (BFA). Overall, greenhouse farming has potential to optimize the use of land and water, and address challenges related to food security, rural-urban migration, climate change, unemployment and chronic poverty (Parry et al, 2009). Adoption of greenhouse farming is regarded highly as an embodiment of productivity, profitability and sustainability.

The tremendous growth in the horticulture sub-sector in Kenya in the recent past is evidenced by earning of foreign exchange, creation of employment, generating family income and other positive benefits which directly and indirectly boost economic growth (HCD, 2010). This aligns with the government development strategy stating, "agriculture ministries are tasked to ensure producers, farmers, processors and marketers of agricultural produce utilize the most advanced methods and technologies".

Conventional farming which involves growing crops in the open field has proved difficult since it involves large farming area, labour intensive and use of large volumes of water (Beibel, 1960). In some places, soil is unavailable for farming while unfavorable geographical or topographical conditions makes fertile and cultivable arable lands scarce elsewhere. (Beibel, 1960). With declining arable land caused by poor land management leading to degradation

worsened by the growing population, people are forced to turn to advanced technologies like greenhouse farming technology to create alternative channels of crop production (Maharana & Koul, 2011).

The reviewed literature underlines the global outcry on the need to increase agricultural productivity as an effort to address the demands of the increasing world population. Greenhouse farming technology has therefore been offered as a possible solution to help eradicate the food insecurity problem. Studies done in Kenya have concentrated on greenhouse gas emissions. As a result, there is limited information on greenhouse farming more so the factors that influence and limit the adoption of the technology. This calls for an intensive research in Meru County which is endowed with natural resources and the potential for high quality crops.

1.2 Statement of the Research Problem

According to Allen (1993) food security is critical for economic growth and development of a nation. With the current rising trends in population growth and climate change 10-20 percent of the population are likely to be at risk of food insecurity by 2050. According to Parry et al (2009) climate change will alter water availability, increase the spread of pests and diseases, shift crop distribution and likely to impact negatively on crop yields in developing countries (Gerald et al,2009). The adoption of improved agricultural technologies is considered a means of alleviating extreme poverty and hunger hence Parry et al (2009) argues that opportunities may emerge to support food security programs for small holder farmers.

Greenhouse farming has been promoted on the basis of its ability to ensure crop production throughout the year and high productivity (Nyalala et al, 2005). It gives small holder farmers and their workers an assured throughout the year employment, employee satisfaction and higher crop productivity. Despite the known benefits of greenhouse farming, small holder farmers have not adopted the specialized technology as it would be expected.

A study conducted by Wambui, (2012) in Mirigamieru East of Meru county on the factors influencing the adoption of greenhouse horticulture found that contact with extension officers, availability of resources, and access to agricultural credit to be positively associated with adoption of greenhouse farming. Alinyo (2014) did a similar study in Kisii highlands and found that adoption and performance of greenhouse farming was influenced by factors such as education, training and experience with the technology as well as use of quality inputs like hybrid seeds and fertilizer.

A study in Embu County by Nkirote (2016) on sweet potato production found that smallholder farmers faced challenges such as lack of information, lack of credit and inadequate experience with new technologies. A study by Kipkorir (2013) at Eldoret East sub county point to limiting government policies and failure to diversify in crops grown as the other factors that hinders performance after adoption of greenhouse farming by among smallholders.

Based on these studies it remains unclear whether other factors such as inadequate skills among farmers to effectively use greenhouse farming, inadequate extension service for farmers, failure to adopt greenhouses suited to the region or indeed any other factors have played influential roles in the decisions of Central Imenti Sub county small holder farmers.

This study was conducted with a view of understanding and documenting concrete reasons for low adoption of greenhouse farming by small holder farmers in Central Imenti Sub County. These findings from the study aimed at helping stakeholders to make pro-greenhouse farmer decisions, a key aspect of improving national and local food security and to inform debates on the nature and kind of support that farmers need to successfully adopt greenhouse farming.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to profile the factors which influence the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County.

1.3.2 Specific Objectives

The following specific objectives guided this study:

i. To establish the extent of adoption of greenhouse farming by small holder farmers in Central Imenti Sub County.
ii. To determine the factors influencing the adoption of greenhouse farming by the small holder farmers in Central Imenti Sub County.
iii. To assess the approaches optimized by the small holder farmers in Central Imenti in order to overcome the constraints of adoption of greenhouse farming.

1.4 Research Questions

The study addressed the following research questions:

i. To what extent have the small holder farmers in Central Imenti Sub County adopted greenhouse farming?

ii. What are the factors influencing the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County?
iii. What are the approaches optimized by the small holder farmers in Central Imenti in order to overcome the constraints of adoption of greenhouse farming?

1.5 Study Hypotheses

i. $H0_1$: There is no significant relationship between technical skills and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County.
ii. H02: There is no significant relationship between agricultural extension support and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County.
iii. H03: There is no significant relationship between availability of resources and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County.

1.6 Justification of the Study

Several studies have been conducted in Kenya and the rest of the world to determine why farmers may not adopt agricultural innovations. However, no studies have been carried out in Central Imenti sub County to establish on why greenhouse farming has not been well adopted by majority of small scale farmers. With little information documented on greenhouse farming in the study area and in the absence of clear cut factors influencing adoption of the same, then an in depth research became necessary.

The data collected and the findings were meant to bridge the knowledge gap created by researches from different regions as well as recommend on future studies on greenhouse farming technology in other parts of the country therefore adding to the body of knowledge available to all. The study aimed to generate useful insights to be used by the farmers, the government and the non-governmental organizations in promoting better ways of food production for food security and creating employment to the youth and women. The study aimed at giving timely recommendation which well implemented could help in the realization of vision 2030, achieve SDG's and support the implementation of the Kenyan big four agenda.

The farmers are to realize and be motivated to tap from the benefits derived from their investment on the expensive technology including increased yields from crops and ability to grow crops throughout the year. The policy makers and planners are to find reason to consider

supporting the small holder farmer to adopt the technology geared towards achieving consistent food security. The other stakeholders are to realize the resulting benefit of supporting the small scale farmers' e.g. better payment of extended credit facilities by the farmers from the sale of produce. This applying to the banks and credit institutions.

1.7 Scope and Limitations of the Study

This study focused on the factors influencing the adoption of greenhouse farming by small holders excluding other factors and the large scale farms. The small holder farmers were selected randomly in Central Imenti Sub County and no other Sub Counties in Meru County where greenhouse farming is practiced. The study aimed at finding the approached optimized by the small holder farmers in Central Imenti Sub County in order to overcome the constraints to adoption of the technology. This study focused on small holder farmers who mainly aim at achieving self-sufficiency in food production for their families as well as generating some income from the sale of the surplus. The area of study was identified for being rich in natural resources and bearing the potential for high quality crops thereby expected to give the expected feedback as guided by the objectives of the study.

One of the limitations of the study was that the area of study is located in a rural set up and that findings differed from a study carried out in an urban setting hence any generalization was done with caution. There was no guarantee that the respondents would return all the questionnaires fully completed neither any assurance that the interviewees would respond to all the questions put forward to them comprehensively. The study area was partially covered due to limitation from time and resources which did not allow research on all other factors that affected the performance of greenhouse farming hence samples taken were used to represent the entire study area. The other factors not addressed can be a focus for another study.

1.8 Assumptions

This study assumed that the sample population drawn would not only be willing and ready to participate in the study but also honest and able to understand questions in the questionnaires and interview schedules, and that they would respond objectively so that information gathered would be valid. It was also assumed that the small holder farmers sampled gave a representative picture of the situation as it is in Central Imenti Sub County. It was assumed that the farmer groups and individual farmers were operating in similar marketing arrangements and experiences, similar agro-ecological environment and weather conditions.

1.9 Operational Definition of Significant Terms

Adoption	A process that begins with awareness of the technology followed by series of steps and decision that a farmer makes leading to effective usage.
Food security	A status where one has reliable access to sufficient quantities of nutritious and affordable food guaranteeing a healthy and active life.
Greenhouse farming	The practice of cultivating crops in an enclosed structure made of transparent material where moisture and temperature is regulated providing a suitable environment for the growth of plants.
Small holder farmer	A person who produce crops and livestock on a small piece of land (1-3 acres) which addresses the source of household food as well as source of income from the sale of surplus.
Technology	The scientific knowledge used in practical ways in the industry e.g. in agriculture embracing technology implies use of the modern farming methods, improved varieties, hybrids and farming machines.

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter highlights the literature review and empirical literature on the factors influencing the adoption of greenhouse farming by small holder farmers. The chapter is organized in terms of the adoption of greenhouse farming and its importance, the factors influencing the adoption of greenhouse farming by small holder farmers, the benefits of greenhouse farming based on which farmers can optimize and concludes with a summary of the chapter which brings out the gaps in the knowledge and focus of the study.

2.2 The Adoption of Greenhouse Farming and its Importance

The global statistics on Greenhouse farming indicate that over 50 countries in the world undertake greenhouse cultivation of crops on a commercial scale. Some of these countries leading in greenhouse farming include China with 2.76 million hectares, Netherlands follows with 89,600 ha, Korea at 57,444 ha, Spain with 52,170 ha, Japan at 49,049 ha, Turkey with 33,515 ha, Italy having 26,500 ha, Mexico at 11,759 ha, France with 9,620 ha, and United States of America (USA) having the least at 8,425 ha (Kacira, 2011).

According to Kacira (2011) the technology permits crop production in places where the winter seasons are so severe and extremely cold such as in Canada and in former Union of Soviet Socialist Republics (USSR). Greenhouse farming also allows farming in places where the summer seasons are extremely intolerable such as in Israel, Kuwait and the United Arab Emirates (UAE).

It is made possible to grow crops in Philippines where excessive rains are experienced by use of greenhouses. In Israel greenhouse farming is widely practiced due to scarcity of water and land boosting the incomes of rural households. The area under greenhouses in Spain is mostly used for the production of vegetable crops like tomatoes, watermelon, capsicum, beans, strawberries and cucumbers.

The greenhouse industry caters for the off-season vegetable markets and flowers in Canada. The tomatoes, cucumbers and capsicums being the main hydroponically grown vegetable crops in the Canadian greenhouses find greater preference with the consumers thereby fetching twice than the regular price of greenhouse produce. The Dutch greenhouse industry is the most advanced in the world and one of the largest exporter of flowers and vegetables all over the world with about 89.600 ha being covered by greenhouses.

Greenhouse farming happens to be at the initial stages in most African countries but increasingly becoming popular. Egypt is leading with about 1000 ha on greenhouses and which are plastic covered tunnel structures with natural ventilation for regulation of temperature and humidity conditions done. The statistics on Greenhouse farming in Southern and East African countries is very scanty. This happens since the countries practicing greenhouse farming fail to document leading to lack of information for comparison. In Kenya, most greenhouses are found in Nakuru, Eldoret, Koibatek, Nairobi around Athi river and parts of Central Kenya (Thika, Embu, Limuru), Baringo, Rift valley around lake Naivasha and tea estates in Nandi Hills and Kericho where multinational and large scale companies began doing large scale flower farming majorly for the export market and partly the local market.

According to Vleeschouwer (2001), greenhouse farming refers to any agricultural farming carried out in a greenhouse. Farmers are facilitated to grow different crops even when climate is not favorable for farming. The major advantage of greenhouse farming is the ability to control temperature and moisture. Farmers can improvise local materials which maximize on heat from the sun to make greenhouses. However, some farmers operating under very cold climates adopt artificial heating where heaters are placed inside the greenhouses to regulate the temperatures (Vleeschouwer, 2001).

Greenhouses are initially designed for plants requiring special growth conditions and often used for the propagation and growing of horticultural crops including vegetables, fruits and flowers, for plant research and for isolating plants from disease or insects. Tender or out of season plants are protected against excessive cold or heat while under greenhouse. Crops are protected from adverse weather, dust, storms, pests and intruders aiming to steal produce. Unsuitable parcels of land are made suitable for the production of crops by use a greenhouse where light, humidity and temperature is controlled thereby improving food production.

Artificial heating of greenhouses is not common in the topics of Africa unless for a few circumstances where a greenhouse can be justified because of the optimum growing conditions required for a high value crop or a research project. Tomatoes, chilies, peppers and egg plants which are termed as high value crops are normally planted under greenhouse in order to recover the huge investment. The seed industry for crops like cabbage, broccoli, Brussel sprouts, radish, beets and cauliflower rely on greenhouse farming to consistently provide seedlings for sale.

According to Vleeschouwer (2001) greenhouse farming is more flexible compared to conventional farming. It is a venture which offers throughout the year employment to the workers, consistent and high productivity from the crops. The crops that can be cultivated under greenhouse are many including herbs, carrots, onions, beans, strawberries, sugarcane, sweet potatoes, citrus, cucumbers, bamboo seedlings, Irish potatoes among others (Onder, 2009).

2.3 Factors Influencing Adoption of Greenhouse Farming by Smallholders

2.3.1 Knowledge, Skills and Experience with the Technology

Education play a very big role in the development of individuals and the society. It is one of the strongest instruments needed to reduce poverty, build gender equality, improve health and enhance peace and stability[7] hence directly linked with agriculture output. Literature from some of the developing countries has demonstrated that with increased literacy farmers are able to understand information and calculate quantities of inputs correctly in the dynamic farming environment.

The willingness to accept the involved risk in adoption of innovations, to consistently save for the investment and embrace productive farming practices is only enhanced with a positive attitude. Adoption of technological innovation by small holder farmers is positively related with the number of years spent in school. Education builds the ability to access information from external sources and through experience with new technology. Knowledgeable farmers are able to learn on the job more efficiently compared to illiterate farmers. Rosenzweig, (1995) Nabhumba and Bahiigwa, (2003) discovered that the level of education attained by the household head is very important.

Philip and Marble, (1986) observed that educated farmers are able to interact with credit agencies better. This is based on their understanding of financial transactions and with up to date kept records increasing the chances of obtaining credit.

The benefit from education is equally felt by other members of the household and neighborhood. Other farmers may adopt the agricultural practice from their educated and experienced neighbor (Jamison *&* *La*wrence 1982*).* Application of the general skills acquired

[7] ***See[7]www.worldbank.org (accessed on 15/07/2018)***

in school overcome the inefficiencies in production while maintaining the positive attitude promotes the likelihood of adoption of new technologies (Husain & Byerlee, 1995).

Both studies agree that the level of education for smallholder farmers has a significant and positive influence on the adoption of new technologies. The farmer's attitude and thoughts are elevated by higher education making them more open, rational thereby better in decision making and willing to evaluate the benefits from a new technology.

Education enables farmers to be rational in decision making on the technology they chose to pursue based on the benefits observed. This makes the introduction and adoption of a new innovation easier. Education and training motivates a farmer in setting the pace by being an early adopter of innovation while shaping the extent to which the new innovation is applied. The educated and experienced farmers are affluent and less likely to experience the danger of starvation in the event a prospective innovation fails.

Educated farmers have a higher chance of being contracted by agricultural extension workers who could be interested in model farmers to test innovations. Literate farmers easily acquire information on a potential innovation thereby making risk evaluations involved in trying out the new methods, crops or farm inputs.

According to Yuan (2010) integration of modern, science based technologies in addition to the traditional knowledge by involving farmers in the innovation process is necessary for sustainable agriculture. The pathway leading to agricultural productivity involves building the capacity of the small holder farmers to innovate while adopting new technologies.

The small holder Farmers and local communities are rich in indigenous knowledge, skills, expertise and agricultural practices related to agricultural production guaranteeing on consistent food security. Traditional knowledge is very essential in farming, however it requires additional skills acquired through training and extension service providers for the poor people to be agents of their own development. The collaboration between traditional knowledge and modern science and technology as promoted by FAO is likely to enhance the sustainability of world's food production and agricultural diversity.

According to Hussein et al (1995) who studied on the response by farmers to contact with extension support, technology adoption behavior from farmers and extension service were directly linked. The study by Hussein investigated the influence of farm visits and training on the adoption of improved wheat by farmers concluding that knowledge and adoption of the same was boosted by the visits and trainings received. The study by Hussein recommended on

the need by the government to strengthen and align the extension provision service to address the needs of the mall holder farmers who rely on the information given by the technical experts.

These findings are supported by Braun (2011) after conducting a pilot farmer field school program on potato integrated pest management practices in Peru realizing that farmers who joined the program were more knowledgeable on IPM than the farmers who did not enroll.

Education is the most valuable asset motivating the rural people to pursue opportunities in new agricultural innovations. However, education levels in the rural areas tend to be characterized with low education levels worldwide which limits the small holder farmers from adopting new technologies like greenhouse farming due to limited knowledge.

It is obvious that most agricultural technologies would best be disseminated through a good agricultural extension service, unfortunately lacking in most countries. Effective dissemination of such technologies calls for a multi-sectoral approach involving different players like the Ministry of agriculture and other policy makers. The participation of the Private sector in provision of extension service also need to be enhanced.

2.3.2 Availability of Resources Needed to Adopt Greenhouse Farming

The biggest limitation to farmers willing to embrace greenhouse farming is how and where to source greenhouses from. Lack of knowledge on where new technologies can be sourced remains the major setback serving as a barrier for small holder farmers in their efforts to adopt new farming technologies. Greenhouses can either be imported or bought locally. Due to lack of collateral the small holder farmers may not seek credit even when interested in adoption of an agricultural technology (The organic farmer, 2011).

The micro finance revolution which provides access to credit minus formal collateral has boosted millions of people. The micro finance institutions, SACCO's and established financial institutions are recognized as the formal sources of finances to the small holder farmers. The informal finance sources include borrowing from family members, friends, marketing agents and shylocks. A farmer who ever received credit is a better measure of credit access than whether there is a source of credit available to the farmer. This is according to a study carried out by Doss, (2006) on the challenges and opportunities for improving technology adoption using micro-studies.

The size and the quality of the land that a family has at its disposal determine the production potential and the economic well-being of the family. As the size of land owned increases, farmers rate of adoption of new farming technologies increases. Farmers with bigger land possess economic resource and consequently, greater risk taking ability compared to the farmers with small parcels of land.

The amount of water needed for agricultural farming is quite significant with most provided by rain, rivers and lakes. Destruction of catchment areas through land degradation worsens water shortages in the rivers posing a challenge in provision of quality and sufficient water for agriculture, industrial and domestic use. Climate variations evidenced by erratic rainfall has led to crop failure and a shift to irrigation practices. The ever increasing population is likely to be accompanied by increased water shortages and farmers faced by water constraints are less likely to adopt new technologies like greenhouse farming where sufficient water is a necessity.

The obvious disadvantage of greenhouses is the prohibitive cost which is unaffordable to many small holder Kenyan farmers whose incomes are low. In Kenya for example several companies sell one greenhouse for approximately US $2000 which is out of reach for subsistence farmers. The cost of buying greenhouses depends on proximity to the materials. This means that imported greenhouses are more expensive than the locally available ones. All the requirements are costly and unequally distributed limiting small holder farmer's ability to compete. According to Riches (1999), a bigger greenhouse leads to more production of produce and better returns. However, the construction cost of the greenhouse varies with its size.

The findings from the study done by Deininger and Okidi (1999) found and documented that adoption of technologies is capital intensive and only affordable to the wealthy farmers hence adoption of new technologies is limited to the rich farmers who can afford. This indicates that adoption of any new technology is dependent on the cost and whether the farmers have the required resources needed to adopt the technology. Farmers with a consistent monthly income are most likely to adopt new technologies like greenhouse farming which require a huge startup capital for greenhouse installation, drip irrigation, cost of seeds, fertilizers and pest control products.

Financial constraints arise from lack of asset ownership which serves as collateral. Lack of credit translates into inadequate working capital and farmer inability to purchase productivity enhancing inputs like hybrid seeds, fertilizers and machinery. Deininger and Okidi (1999) from their study documented that credit limits granted by formal lenders were relatively small

in relation to what is required for one to invest in greenhouse farming therefore recommended gradual increase on the loan granted for repeat borrowers.

Establishing a commercial greenhouse may be labor-intensive and costly. Investing Ksh. 120,000 (1185 USD) in a greenhouse business may rake in up to Ksh. 1.2 million (11,900 USD) annually, thanks to the efficient technology which keeps adverse weather and pests at bay. The cost of greenhouse polythene in Kenya is Ksh. 150,000 (1482 USD). The government has introduced miniature greenhouses that cost as low as Ksh. 40,000 (395 USD) which favour the small holder farmers who many not afford the bigger greenhouses at the start of the venture.

Most farmers in Kenya who deal with horticultural products such as capsicum, onions, and tomatoes have managed to become instant millionaires with this venture. For instance, a single tomato plant may yield between 16 and 20 Kgs with the current market rate for a kilo of fresh tomatoes going for about Ksh. 150- Ksh. 250 (1.50-2.47 USD). One square meter of the crop may fetch about Ksh. 3,000 (30 USD) with an average greenhouse earning about Ksh. 400,000 (3950 USD) per harvest. (Nyalala et al, 2017).

2.3.3 Interaction with Technical Experts

The advice and assistance to farmers geared towards helping them improve their methods of crop production and marketing is called agricultural extension. Farmers need to be supplied with up to date and practical information related to agriculture. Rural people get persuaded into adopting improved methods of farming for improved crop and livestock productivity through agriculture extension service. (NALEP1, 2011). The scope of agriculture extension is recently changing from the mere emphasis on technology transfer to a broader concept which involves developing learning capacity and management abilities of both small scale farmers and extension service providers (Swanson, 2008).

Agriculture extension provides a link between farmers and research institutions, while transmitting knowledge pegged on local experience for further implementation (NALEP2, 2011). It is proved that Greenhouse farming technology requires close monitoring, control and special management involving even extension service support to succeed (Janick, 1986). Extension service remains the only source of agricultural information in most cases and promotes embracing of new technologies by small holder farmers. The extension materials in use require to be regularly reviewed to meet the farmer’s demands while facilitating the changes in farming technology (Muturi, 1999).

In the developing world the ability of small holder farmers to innovate, make a decision towards adopting new technologies while acquiring better farm management systems is the only pathway to improved agricultural productivity, sustainability and profitability. The farmer's ability to innovate is based on their access to sources of information and knowledge. The rural agricultural extension addresses the immediate needs of the small holder farmers facilitating their change of livelihood and production system. Kenya plant health inspectorate service (KEPHIS) established that farmer education, extension visits, and attending field demonstrations relates positively with adoption of improved maize innovations, and applying of up to date pest control measures against upcoming pests and diseases. Demonstrations through field days and meeting with extension staff are the most important sources of information for farmers[8].

According to Kenmore and Halwart (1998), providing the small holder farmers with technical information which promotes their productivity and improves their livelihoods helps in building their capacity. Several non-formal educational methods used to create awareness to small holder farmers include mobile phones, radio, television, night schools, print media, movies/plays and internet. This also includes the recently launched e-Extension in Kenya. Farmers gain their skills, expertise, knowledge and competences from NGOs, government agencies, research institutions, input suppliers, private extension providers and fellow farmers.

The potential to innovate for farmers who are scientists in equal measure can be realized if they are given opportunity and motivation. This can be done through farmer participatory research approaches which encourage them to conduct research using their own resources to develop appropriate innovations. Media can assist small holder farmers to disseminate the acquired information to their fellow farmers and other interested parties. Some of the identified ways of creating awareness to the small scale farmers include newsletters, posters, farm visits, radio, television programs and billboards in local languages[8]. Organizing Farmers into groups guides them into consolidating their efforts to address their problems communally through forums and enables them access information, markets and negotiate for best prices for their products and cheaper prices for farm inputs (Kenmore & Halwart, 1998).

[8] *See[8]www.kephis.org (accessed on 20/03/2018)*

2.4 Approaches Optimized by Smallholders to Overcome the Constraints to Adoption of Greenhouse Farming

According to Vleeschouwer (2001), greenhouse farming refers to any agriculture activity carried out inside a greenhouse. This allows farmers to grow different kinds of crops even where climate may not favour crop production. The biggest advantage of greenhouse farming is the ability to control temperature, humidity and other conditions suitable for plant growth. Farmers can make greenhouses using materials that maximize the heat from the sun or use heaters which can be useful in very cold climate (Vleeschouwer, 2001).

Greenhouses are designed for the protection of tender or out of season plants against extreme cold and heat or growing plants that require special growth conditions. Light and temperature control allows green houses to transform unsuitable lands making them fit for production of crops thereby facilitating sustainable food production.

The organic farmer (2011) magazine noted that small holder greenhouse farmers need capital or security to get a bank loan to start greenhouse farming both of which are not available. Organizing small holder Farmers into groups helps them to consolidate their efforts to address their problems communally through convening forums with extension officers which enables them access information, markets and negotiate for best prices for their products and cheaper prices for farm inputs (Kenmore & Halwart, 1998).

According to the study done by Doss (2006) off farm income facilitate adoption of improved technologies. However, the efficiency gains from adopting such technologies may be undermined by the limited time that the famers with off farm income sources allocated to the farming initiative. The small scale greenhouse farmers with other sources of income struggle to strike a balance between their farming venture and other sources of income.

Greenhouse farming allows farmers to take advantage of the vertical space unlike under conventional farming where the farming space is normally a flat expanse. Many small holder farmers have plants sitting on shelves or hanging from the ceilings which allow the farmer to pack more plants in a small area thereby addressing the food security situation (Vleeschouwer, 2001).

Onder J. (2009) documented that crops such as sugarcane, sweet potatoes, Irish potatoes, onions, French beans, green bean, carrots, cucumber and bamboo seedlings could be cultivated under greenhouses. This brings up the concept of diversification into other crops by the small holder farmers in order to promote food security instead of relying on farming tomatoes as the

only crop. These alternative crops can also be used on rotation basis eliminating the chances of pest build up in the greenhouses.

Growing crops under greenhouse conditions compared to an open field, can enhance quality, multiply production and enable growers cultivate their crop over a longer period of time. When greenhouse farming is carried out correctly, it can significantly increase yields over what is possible under open field production. For example, greenhouse tomato yields four to five times more than open field (Organic Farmer, 2018).

It is proven that farming under a greenhouse extends the growing season for a crop even up to eight more months compared to farming under the open field system which fully depends on the weather conditions that must be favourable for crops to survive. The temperature and humidity under a greenhouse is regulated promoting faster maturation of the crops and stronger growth during the initial stages of plant growth. The small holder farmers regulate temperatures by use of natural materials which readily absorb and release heat to the crops gradually while others use man made heaters and fans in their greenhouses. (Vleeschouwer, 2001).

Vegetables are an on and off season crop and their prices in the market fluctuates according to demand, availability and production methods. Adopting a greenhouse by the small holder farmers provides a perfect opportunity to supply the market with vegetables and fruits during the off season creating an enhanced supply to meet the demand from the customers. It also facilitates growing of crops like strawberries that normally do not survive under the local climate. (Organic Farmer, 2018).

Crops grown under a greenhouse set up are guaranteed of protection from harsh weather conditions, pests and diseases. This comes as a result of the enclosed status of the greenhouse giving the crops an advantage compared to the open field crops where some pests and diseases occurs naturally in the environment. The risk of soil borne diseases is minimized when farming under greenhouse e.g., for tomatoes, diseases spread faster when wet soil is splashed its leaves as it rains or when overhead irrigation systems is used. The drip irrigation used in greenhouses reduces the amount of moisture on the tomato leaves minimizing the risk of fungal tomato diseases that thrive better on wet foliage. It’s much easier to manage and control pests, birds and diseases under a greenhouse set up compared with open field tomato farming. (Vleeschouwer, 2001).

Efficient utilization of water is achieved by use of the drip irrigation which is normally recommended for greenhouses where Water is directed to the stem of the plants, checking out on surface run-off, preventing soil clogging and ensuring uniform distribution of water. The survival of weeds in a greenhouse is checked by denying them water and as a result less labour is covered when tending to the greenhouse crops (Organic Farmer, 2018). Greenhouse farming eases the work involved in the management of crops like tomatoes which require staking to grow upright and support the weight of the fruits. A greenhouse safeguards the produce from thieves who are able to tell when crops are ready for harvesting.

Regular monitoring of the greenhouse covering for tear and breaks, restricted entry, closing of the greenhouse doors and use of footbath at the entrance helps in locking out pests. This ensures minimal need for pesticides, lowers the cost of buying pest control products and minimizes the risk of harmful chemical residues on the produce, making them more quality and safer for human consumption. Having a greenhouse helps in pest management but consistent monitoring to ensure the crop is pests and disease free is deemed necessary since entry of pests like whiteflies and diseases like Botrytis spreads so quickly to the rest of the plants (Organic Farmer, 2018).

Greenhouse fish farming technology has been introduced in Meru, Nyandarua and Laikipia counties for warm water fish which thrives better at the temperatures ranging between 20 and 25 degrees Celsius to breed and mature faster earning farmers' profits after their sale. (FAO, 2018). Organic farming is best done under greenhouse technology in order to provide the much needed care to prevent and control common crop diseases and pests. The cost of organic greenhouse production is low compared to conventional greenhouse production (Organic farmer, 2019).

2.5 Empirical Literature

KEPHIS (2017) established that farmer education, extension visits, and attending field demonstrations relates positively with adoption of improved maize innovations, and applying of up to date pest control measures against upcoming pests and diseases. Demonstrations through field days and meeting with extension staff are the most important sources of information for farmers[9].

[9] *See[9]www.kephis.org (accessed on 20/03/2018)*

A study conducted by Wambui, (2012) in Mirigamieru East, Meru county on the factors influencing the adoption of greenhouse horticulture farming found that contact with extension officers, availability of resources, and access to agricultural credit to be positively associated with adoption. Alinyo (2014) in his study in Gusii highlands highlighted use of quality agriculture inputs, Farmers training and availability of consistent and informed extension service as key influencers to the performance of greenhouse farming technology by small scale farmers.

Nkirote (2016) while investigating on the challenges facing small scale farmers in adopting new technologies in sweet potato production in Embu County discovered the important role played by the existing government policies. A study by Kipkorir (2013) at Eldoret East sub county points to the limiting government policies and failure to diversify in crops grown as some of the other factors that limit the adoption of greenhouse farming among smallholders.

A study conducted by Dwasi (2017) in Gem Sub county on the factors influencing adoption of greenhouse farming technology among the small scale horticulture farmers found that access to capital, technical skills, availability of market and technology characteristics influenced adoption of greenhouse technology among small scale farmers recommending the need to increase small holder farmer's capital and availing credit facilities to them. His study recommended to the government on the need to improve institutional and infrastructural development to ensure broad-based, low cost market access and well-functioning input and output marketing.

A study seeking to investigate the determinants of sustainability in greenhouse farming technology amongst farmers in Kakamega County by Atieno (2013) recommended sensitization and strengthening on the concept of integrated pest and disease management system in greenhouse farming technology, utilizing the renewable energy sources as a way of reducing the cost of fuel used greenhouse farming technology and adoption of modern irrigation system to enhance the sustainability of greenhouse farming technology.

Mwendia (2019) in his study investigating the drivers of diversification into banana farming by farmers among households in Meru County observed that higher education attainment, improved monthly income, and bigger land size influenced the diversification into profitable banana farming moving away from subsistence farming. His study documented that lack of sufficient farmer support systems such as lack of water and farm inputs remained a major constraint for many farmers. He further recommended the need for the government to develop

and implement policy guidelines which create a supportive environment characterized by proper market price regulation, supply of water to the farms and easy access to production inputs by the farmers.

The Kenyan big four agenda (BFA) where Food security is one of the targets is a big motivation to the small holder farmers in adopting new technologies like greenhouse farming for improved yields, better quality and consistent production throughout the year.

2.6 Summary of the Literature Review, Gaps in Knowledge and Focus of the Study

From the reviewed literature it was apparent that despite education being the most valuable asset which motivates the rural people to pursue opportunities in new agricultural innovations, education levels in most rural areas are characterized by low education levels. Building the capacity of small holder farmers to innovate and adopt new technologies was the only pathway leading to agricultural productivity.

Traditional farming systems and indigenous crops are endangered following commercialization of agriculture, growing population, land use changes and the impacts of climate change. Collaboration between farmers and extension service is critical to strengthen the interface between traditional knowledge and modern science and technology. This will enhance the world's food production, agricultural diversity and sustainability.

Farmers have problems accessing information on greenhouse farming technology leading to reliance primarily on other farmer's experiences or trial and error approaches to determine the suitable conditions for greenhouse farming. Greenhouse farming technology requires close monitoring, control and special management to succeed. Just like any other agricultural technology, greenhouse farming can best be disseminated by using the existing agricultural extension service which is unfortunately lacking or demand driven in most counties including Central Imenti.

There is inadequate information available on the clearly cut factors that influence the adoption and performance of greenhouse farming by small holder farmers. This called for this in-depth research in central Imenti Sub County, the study area endowed with natural resources, well known to the researcher and with the potential for high quality crops. With little information documented on greenhouse farming in the study area, then an in depth research was deemed necessary. The data collected and the findings were to bridge the knowledge gap created by researches from different regions as well as recommend on future studies on greenhouse

farming technology in other parts of the country therefore adding to the body of knowledge available to all.

2.7 Theoretical Framework

2.7.1 The Malthusian Theory of Population

The Malthusian theory of population expounds on the exponential population growth as well as the arithmetic food supply growth. The theory was published by Thomas Robert Malthus, an English cleric and scholar in his 1798 writings which was presented in form of an essay titled, "An Essay on the Principle of Population". The scholar examined on the relationship between population growth and availability of resources. The essay was summarized by these statements:

Food is a necessity for the existence of man and exercises a strong check on population.

The rate of population growth outgrows food production. The rate of population increase follows the geometric progression while food production follows the arithmetic progression.

The instinct to increase at a faster rate is natural hence when the means of subsistence increase there is the tendency of population to increase unless managed by some powerful checks.

Preventative and positive checks can keep population maintained within the means of subsistence.

Malthus argued that population doubled every generation when its growth is unchecked hence the number will grow exponentially in 1-2-4-8-16 ..... up to 256 by the 8th generation. At the same time, the means of subsistence will increase with arithmetic progression of 1-2-3-4-5 …. Up to 9 by the 8^{th} generation. Malthus concluded that the balance could only be maintained if positive checks or preventative checks periodically checked the population to balance the food supply with the population level at a sustainable level. This pessimistic view was accepted by other 19^{th} century Scholars in Europe.

However, the catastrophe forecasts put forward by Malthus have not played out. In Western Europe, populations have grown not at the rate Malthus predicted and food production has also risen because of technological advancements. Following many technological advancements e.g. use of greenhouse farming, food production has been made possible throughout the year. The scarcity of land formed the basis for Malthus' theory on food production challenges. However, trading of goods and services for food facilitated by globalization has increased the amount of food a country can consume at any given time.

Food production would never match with population growth except by embracing rapid advances in technology, use of fertilizers, pesticides, better seeds, tractors and other agricultural machinery boosting increased production. The rate of increase of food production in most countries has been greater than the rate of population growth. The inventions and advancement in agricultural production methods have beaten the catastrophe predicated by Malthus by holding the law of diminishing returns in check.

Malthus theory neglected the manpower aspect in population growth whereby an increase in population builds on manpower which tends to increase not only agricultural but also industrial production. This translates to a rich country as a result of equitable distribution of wealth and income. Mankind is faced with the prospect of being able to solve the problem of food insecurity. The theory has been highly criticized, as it has not been realistic in most parts of the world. Man's ability to foresee the green revolution, the technological revolution and family planning has disputed what Malthus predicted but the theory continues to be relevant in Africa due to persistent problems like climate change leading to famine and degradation of natural resources which forms the source of food and income to people.

2.8 Conceptual Framework

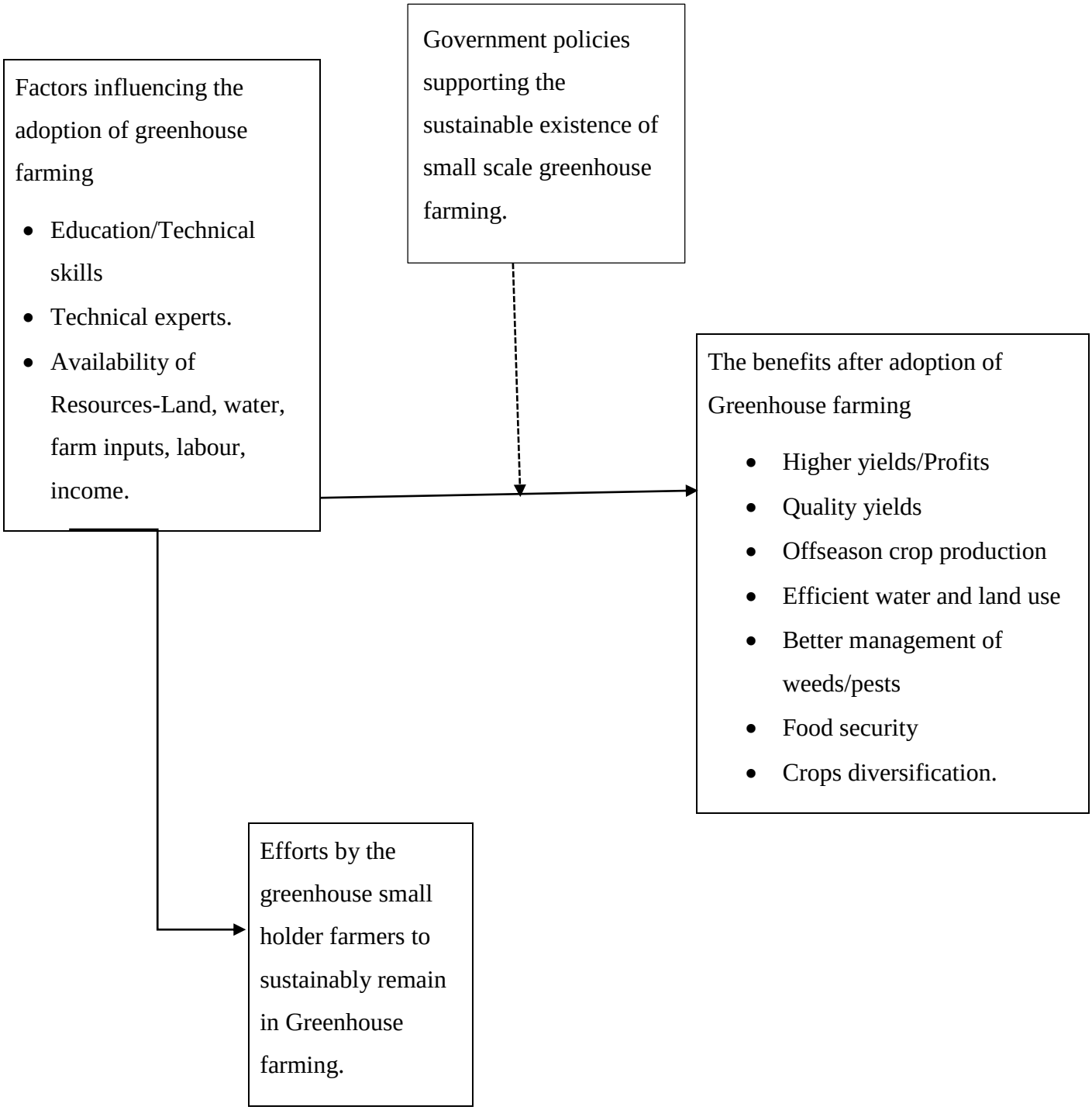
This study focused on one dependent variable which is adoption of greenhouse farming by small holder farmers and one independent variable with factors (like availability of resources like land, water, income, farm inputs and labour, supportive technical experts, Education, training and knowledge on greenhouse farming) influencing the adoption of greenhouse farming by small holder farmers. The study adopted two mediating variables which are the existing government frameworks like subsidy policies, food security policies and the ministry of agriculture policies which complements the efforts by the small holder farmers to sustainably remain in greenhouse farming in order to meet the rising demand for food caused by the increasing population and climate change.

This study aimed at assessing the factors influencing the adoption of greenhouse farming by small holder farmers in Central Imenti Sub County. The study evaluated how availability of resources, interaction with technical experts, farmer's knowledge, experience and training influence the adoption of greenhouse farming by small holder farmers.

The availability of technical experts including the frequency of visits done were assessed. The cost of installation and maintenance of a greenhouse and availability of resources like water, land, farm inputs like seed/crop protection products, financial support and greenhouses suited to the area of study were assessed including the knowledge on where to source them. The age, gender, level of education, training and experience of the farmers in the study area were assessed.

The benefits from greenhouse farming which included higher and quality yields, offseason crop production, efficient use of water and higher returns per unit of land area used were investigated. These come as a result of farmers putting into practice the skills and knowledge acquired through training and experience with the greenhouse technology. The economic status of the farmer was likely to change from poverty, food insecurity to economic empowerment and food self-sufficient. Adoption of the greenhouse technology translates to improved living standards, better nutrition, improved health, good housing and adequate education for the household members as a result of improved agricultural productivity and consistent income. The efforts by the small holder greenhouse farmers to remain in greenhouse farming were assessed.

This explained the conceptual framework that the study used in order to assess the actual situation following adoption of the greenhouse farming technology by the small holder farmers in the study area as an effort towards food production throughout the year. The collected findings formed the basis for giving recommendations on how to address gaps in the model with an aim of enhancing greenhouse farming technology uptake for the benefit of small holder farmers who farm for food and sale of surplus produce for income.



(Source: Researcher, 2020**)**

Figure 2.1: Conceptual Framework of the Study

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter highlights on the research methodology adopted by the researcher in order to achieve the set study objectives. The chapter is organized in terms of description/map of the area of study, research design, target population, sample size/sampling procedure, data collection method/procedure, data analysis techniques, reliability/validity of the research instruments and concludes by a table on the operationalization of variables. The study relied on both primary and secondary data as guided by the study hypothesis, research objectives and questions.

3.2 The Description of the Area of Study

Central Imenti Sub County is located in Meru County which appears east of Mt. Kenya whose peak cuts through the southern boundary of the County. To the west Meru county shares borders with Laikipia County, south west with Nyeri County, to the east with Tharaka Nithi County and to the North with Isiolo County. The total area occupied by the sub county is 381.8 Km^2 with 35,595 households and a total population of 133,818 persons (KNBS, 2019).

The ecological zones for the sub county range from upper highlands, lower highlands, upper midlands and lower midlands. Moderate amounts of rainfall are received by the sub county while the lower parts of Kiagu bordering Tharaka Nithi County are known to be semi-arid. The rainfall distribution ranges from 300mm per annum in the lower midlands to 2500mm per annum in the upper highlands. Two rainfall seasons with the long rains occurring from mid-March to May and short rains from October to December are experienced. Temperatures range from a high of 32^oC and a low of 8^oC during the hot and cold seasons respectively.

The description of the area of study indicated the huge potential of the area to produce enough food to feed the local population and the nation if greenhouse farming was adopted by the small holder farmers as an alternative farming approach.

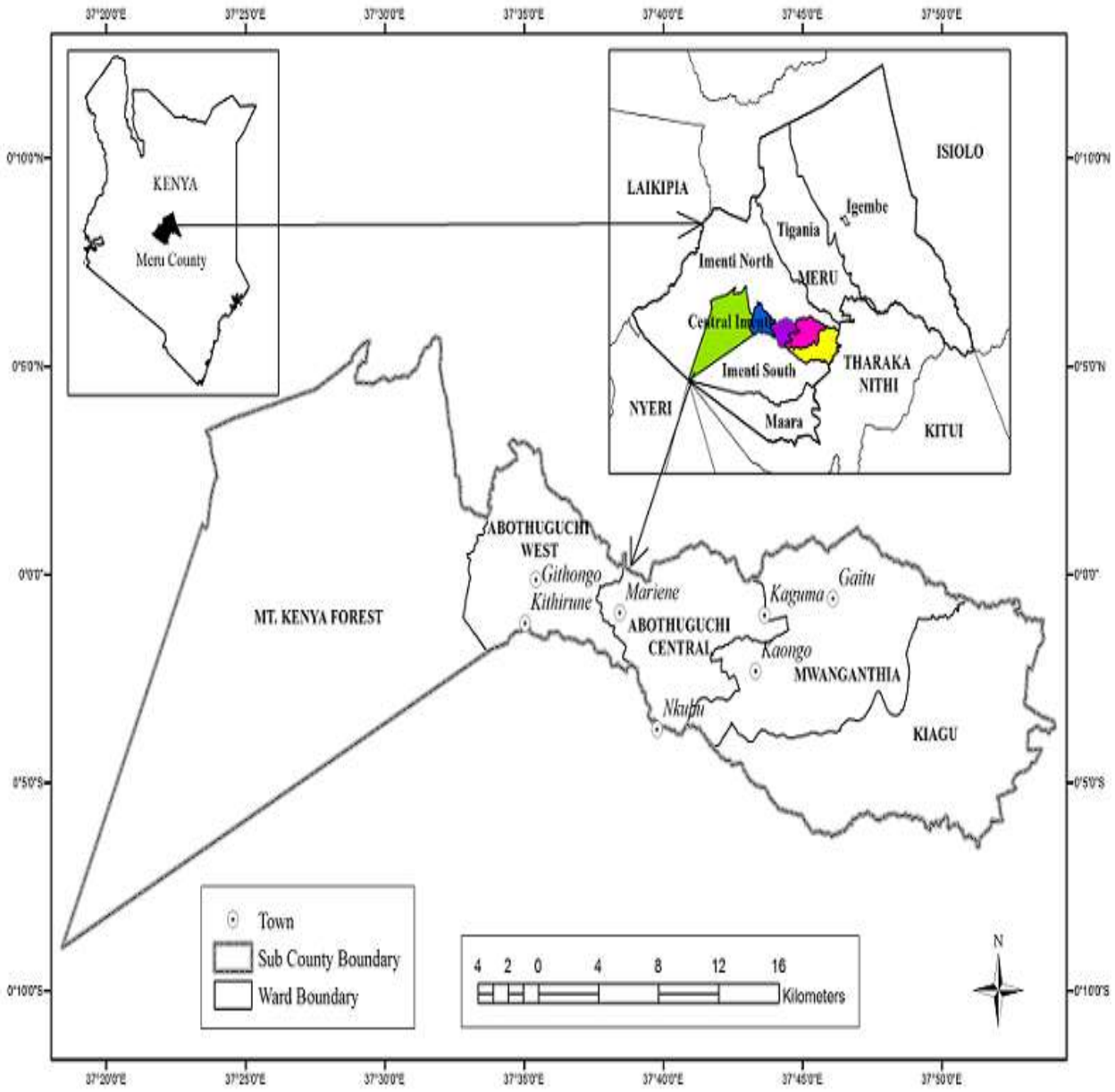


Figure 3.1: Map of the Area of Study (Source-Meru county, 2014)

3.3 Research Design

The study adopted a descriptive survey research design as described by Mugenda & Mugenda, (2003). The design was suited for the study since it involved fact finding and collecting data for analysis from a large population where making observations for each individual was impossible. It was considered an appropriate design due to its ability to collect both qualitative and quantitative data needed for understanding the underlying reasons, without manipulation of treatments. It provided useful insights into the problem and highlighted issues as they existed

on the study area. This facilitated a deeper understanding of the reasons for adoption or failure to adopt greenhouse farming technology by small holder farmers in Central Imenti Sub County thereby achieving the set objectives.

3.4 Pilot Study

A pilot study was carried out in Kithirune Ward which was later excluded from the main data collection for the study. The pilot study provided an opportunity to train the research assistants, determine the validity and reliability of the research tools as well as establish how long it took to conduct the interview. During the pilot study the respondents were asked what they understood by the asked questions highlighting any words they failed to understand on the questionnaire or found offensive. The questions were edited later reflecting the feedback from the respondents. This enhanced on the flow of the questions and minimized the time taken to conduct the interview. The pilot study helped in the finalization of the research tools and drawing the implementation strategies.

3.5 Target Population

This study targeted the small holder farmers in Central Imenti Sub County. Another targeted group of the population included key experts: ward agriculture officers, Head of farmer groups, chiefs, assistant chiefs, Sub-county and County Agriculture officers who are well versed with greenhouse farming issues. The researcher aimed at achieving all the set objectives giving recommendations geared towards making the farmers more proactive both for their livelihood and also making the economy better.

3.6 Tools of Data Collection

Questionnaires, key informant interviews, observations, field visits and photography were used as the primary means of collecting data. Some of the data collected from the sampled population included: Farmers age, gender, education level, training and experience by years, frequency of farm visits by the extension officers, earning from the sale of the greenhouse produce by monetary value and resources owned by the small holder farmers like income, water and size of land in hectares.

The questions on the questionnaire were open ended for qualitative data and closed ended questions for quantitative data. The questions were based on the study objectives and the themes on the literature review section.

3.6.1 Questionnaires

Questionnaires were used by the researcher as the tool used in interviewing the small holder greenhouse farmers. The questions on the questionnaire were closed and open-ended. The areas investigated using the questionnaires include general information about the farmer, age, gender, level of education, monthly income, number of household members, size of land held, crops planted, possible causes of non-adoption, source of greenhouse information and other farmers' attributes that may have influenced adoption of greenhouse farming.

3.6.2 Key Informant Interviews

The key informant interviews were scheduled for the extension officers, greenhouse group heads and village headmen. The interviews allowed the interpretation of the questions, developing rapport with respondents, and facilitated face to face contact between the interviewee and interviewer capturing information on the socio-economic status of the farmers and source of farming information available to the farmers.

3.6.3 Observation

Direct observation was used by the researcher to compare against the captured data on the status of adoption and performance of greenhouse farming in the study area.

3.6.4 Photography

Photography was used to capture the real situation on the ground such as the types of crops grown, the type of greenhouses in use and the performance of the crops in the study area. Photos illustrated better the observations made in the study area.

3.6.5 Secondary Data

Secondary data was referred to extract the data on record on the status of adoption and performance of greenhouse farming in the study area. Books, published reports on greenhouse farming in the study area, census reports, newspapers, journals, and research reports were reviewed from library sources, government offices and internet data base. The period under review was relevant in terms of attaining consistent and relevant information.

The effect of farmer's education level, experience, gender and age on adoption of the technology was evaluated using the data on farmer's highest education level attained based on years spent in school while learning, experience based on the numbers of years each farmers has practiced greenhouse farming and farmer's age based on years.

The contact with technical expertise and its effect on the adoption of greenhouse farming was evaluated by use of data on the number/frequency of extension staff farm visits during the previous season. The challenges faced by the small holder greenhouse farmers and the opportunities to improve greenhouse farming were identified through focused group discussions and interviews involving the key informants who were the Sub-county and ward agriculture extension staff officers and other staff within the county government.

3.7 Sample Size and Sampling Procedure

3.7.1 Sample Size

The Morgan's table and graph (Appendix 1) was used for determining a sample size based on a given population was used. No calculations are needed when using this table. The sample size increases at a diminishing rate as population increases, remaining constant at more than 380 cases (Krejcie & Morgan, 1970). The target population was 133,818 persons and 39,595 households based on the 2019 Census report. Out of this 380 households were picked to be interviewed as derived from the Morgan's table.

3.7.2 Sampling Procedure

Stratified random sampling was used to sample the respondents from the four wards in the area of study. The information on number of households in each ward was acquired from the chiefs and assistant chiefs of the four wards. To select the 380 households studied, the researcher with the help of the village headmen identified the geographical center of the ward. One household at the geographical center was selected to act as the first household to be sampled followed by systemic sampling in which every 5^{th} household along the established road was selected to be interviewed in the four wards. This was done until a total of 380 households were selected and interviewed based on individual population of each of the four wards. This gave equal opportunity to all the individuals in the Sub County to be selected while the results were generalized to the entire population. The researcher factored and sampled the small holder farmers in different categories; gender, expertise and experience in farming, education background and demography within the sub county

The researcher interviewed key experts (County agriculture officers, greenhouse group leaders and village headmen) who were sampled purposively to find out the level of adoption and performance of greenhouse farming in the study area, the challenges faced and what could be done to ensure the small holder farmers remained sustainably in greenhouse farming.

3.8 Data Collection Procedures

380 questionnaires were administered to the sampled respondents on a five-day program organized between the researcher and her assistants. To the famers who could not read and write the questionnaires were administered by reading questions and filling in responses in the spaces provided in the questionnaires. The filled questionnaires were collected for data input and analysis. The agriculture extension officers and other key informants were interviewed by the researcher and her assistants by reading through the set questions on the checklist and filling in the responses on a separate record.

The tools used to collect data included a notebook and pen, questionnaire print outs, camera for capturing the photos (on the type of greenhouses used by the farmers, types of crops grown, abandoned greenhouses) and Laptop used to summarize the collected data for analysis.

3.9 Data Analysis Techniques

The collected data was qualitative and quantitative in nature. The researcher evaluated the responses received from the interviews and questionnaires noting down the feedback in each set of data as per the study objectives and research questions. The researcher analyzed the answers to each question from the different responses and compared it with facts that were already in existence as per the reviewed secondary data on the study topic. The feedback from the administered and collected questionnaires and interviews were first coded by transforming data categories into symbols that were tabulated and counted. The evaluated and coded data was keyed into statistical package for social sciences (SPSS) version 20 for further analysis. The descriptive statistics like frequencies, mean and percentages were generated and the results of the findings presented in form of tables, pie charts, bar graphs. In testing the research hypothesis, chi-square test was conducted. Cross tabulation analysis between the factors considered and adoption of greenhouse farming was undertaken. This was used to make conclusions and recommendations in combination with researcher’s opinion based on the existing body of knowledge on the topic.

3.10 Reliability/Validity of the Instruments

Reliability in this study was ensured by preparing the instruments in such a way that they were split into two. After administration during testing, the responses were scored. The two parts were treated as two instruments. The scores of the two parts were mathematically correlated through the use of the Spearman's Coefficient Correlation. A correlation coefficient found to lie between 0.5 and 1.00 meant that the instruments were reliable.

The research instruments were prepared as per the objectives of the study. This ensured that they were all relevant in capturing the required data. To ensure validity, the researcher used expert judgment of the supervisors in combination with prior testing of the instruments after which questions having problems or likely to give unexpected answers were modified to avoid misinterpretation of the questions.

3.11 Ethical Considerations

The study highlighted the purpose of the study, possible benefits and contact person to address queries/clarifications. The participants were assured of total confidentiality and that information given during the study was to be used for research purpose only. The importance of maintaining confidentiality was equally emphasized to the research assistants. The names of the respondents were to appear nowhere and no personal questions were asked hence the study was considered not risky to the participants. The findings of the study were to be used in planning for greenhouse farming factoring the best ways to involve the respondents.

3.12 Operationalization of Variables

Operationalization of variables involved evaluation of the research questions based on the study objectives, identifying the appropriate indicators, picking on the tools to be used and measurement of the indicators and picking the type and level of measurement of the indicators.

Table 3.1: Operationalization of Variables

Item	Objective	Indicators	Measuring of indicators	Level of scale	Tools of analysis	Type of analysis
1.	To establish the extent of adoption of greenhouse farming by small holder farmers in Central Imenti Sub county.	-Adoption of greenhouse farming.	-Number of famers who have adopted greenhouse farming.	Nominal	Mean Percentages	Descriptive
2.	To determine the factors influencing the adoption of	-Experience, Skills and knowledge on greenhouse farming.	-Years one has been using the technology.	Nominal Ordinal	Mean Percentages	Descriptive Inferential analysis

	greenhouse farming by smallholder farmers in Central Imenti Sub County.	-Interaction with technical experts. -Availability of resources-land, income, water and farm labour.	-Training attended by the farmers. -Frequency of farm visits. -Availability of land in acreage, water based on whether present or unavailable, Monthly income and farm labour based on household members.			
3.	To assess the approaches optimized by the smallholders in Central Imenti sub county to overcome the constraints of adoption of greenhouse farming.	-Marketing of produce from the greenhouse. -Diversification in crops grown. -Greenhouse group farming.	- Marketing options. -Number of crops grown on the greenhouses. -Number of groups doing greenhouse farming.	Nominal Ordinal	Mean Percentages	Descriptive

(**Source-Researcher, 2020**)

3.13 Summary of the Chapter

This chapter discussed on the methodology to be used to conduct the research. The research design to be used, the target population, the data to be collected, the sample size, the sampling methodology, the research instruments and method of data analysis to be used were highlighted. The chapter concluded by giving a table on the operationalization of variables which gives the research objectives, their indicators, means of measuring them, level of scale and type of analysis to be done in order to make conclusions on the findings.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter documents the findings of the research that aimed at assessing the factors influencing the adoption of greenhouse farming by small holder farmers in Central Imenti Sub County in Meru County. Data was analyzed using descriptive tools, findings interpreted and presented using frequencies, percentages, tables, pie charts and bar graphs. Data findings were compared with the researcher's opinion together with the existing body of knowledge for informed interpretation and discussion.

4.2 Response Rate

Out of the 380 questionnaires administered to the sampled respondents, 364 questionnaires were filled completely giving a response rate of 96%. The researcher and her assistants checked for correctness of the filled questionnaires and excluded the participants who were not willing to participate in the study. According to Mugenda (2003), a 50 % response rate from the respondents is good for a social study. Table 4.1 shows the summary on the questionnaire return rate.

Table 4.1: Questionnaire Return Rate

Questionnaires issued	Questionnaires returned	Incomplete questionnaires	Complete questionnaires	Response rate (%)
380	**367**	**3**	**364**	**96%**

Source: Field data (2020)

4.3 Demographic Characteristics of the Respondents

This section presents the demographic characteristics of the respondents. The indicators analyzed include: gender, age, level of education and involvement in greenhouse farming.

4.3.1 Gender of the Respondents

In the African social set up gender is a very important variable to evaluate since it is affected by the social or economic phenomenon just like globalization. Gender was evaluated in this study and the findings presented in Table 4.2.

Table 4.2: Distribution of Respondents by Gender

Gender	Frequency	Percentage (%)
Male	233	64
Female	131	36
Total	**364**	**100**

Source: Field data (2020)

The findings from the study indicated that the majority of the respondents at 64% were male while the females were 36%. This implied there was gender imbalance in the manner in which the males and females practice greenhouse farming in Central Imenti Sub County. The explanation was that the males take a lead role in determining the farming enterprises that their household members engage in. The males own most of the family assets hence likely to invest more capital towards the adoption of greenhouse farming compared to females. This was supported by the observation that most of the households interviewed were male headed. Another explanation is based on gender roles whereby the male members of the household take the field work roles while the female members of the household attend to the household chores.

Plate no. 4.1 Some of the respondents interviewed. Source: Field data, 2020 **Captured on 15th May, 2020.**

4.3.2 Distribution of Respondents by Age

The respondent's age indicates the level of maturity of the individuals hence very important in understanding the opinion and view about a particular area of study. The findings based on the age of respondents in this study were captured in Table 4.3

Table 4.3: The Distribution of Respondents Based on Age

Age (years)	**Frequency**	**Percent (%)**
Less than 25	0	0
25 to 34	40	11
35 to 44	182	50
45 to 54	120	33
Above 55	22	6
Total	**364**	**100**

Source: Field data (2020)

The research findings indicated that none of the respondents were less than 25 years. 11% were aged between 25 and 34, 50 % were aged between 35 and 44, 33% were aged between 45 and 54 and 7% were above 55 years. The findings on the respondents based on age was very important to this study since it influenced on decision making. The respondents aged between 35 and 44 years were the majority at 50% which is basically the middle age associated with high level of productivity and personal growth hence likely to invest more capital and energy to ensure the success of any venture they engage in. A few of the respondents were above the middle age while very few were falling above 55 years. It was important to evaluate the age of the respondents for this study since it indicated their level of encounter and maturity of the individuals hence their decision making and information could be relied on based on their experience in greenhouse farming.

4.3.3 Distribution of Respondents Based on Education

The level of education determines personal attitude and view of looking and understanding some given social phenomena. It is a key determinant of one's response hence influences

decision making. The respondents level of education was evaluated and findings captured in Table 4.4.

Table 4.4: Distribution of Respondents Based on Education

Level of education	**Frequency**	**Percentage (%)**
Never been to school	0	0
Primary school	98	27
Secondary school	226	62
College/university/other trainings	40	11
Total	**364**	**100**

Source: Field data (2020)

The research findings indicate that 11% attained college/university education/other trainings. 62% had secondary school education, 27% had primary school education while none of the respondents had not attained any level of education. It was established that 73% of the respondents had attained either secondary, college/university/other trainings in agricultural farming indicating that most of the respondents were literate.

From this table it was concluded that the respondents were literate, hence could read and understand thereby giving reliable responses to the questions on the questionnaire. Again the number of years spent in school indicated that the farmers possessed some technical skills, experience and knowledge on greenhouse farming hence making them better placed to adopt the technology compared to the farmers who had never been to school.

4.4 Greenhouse Farming by Small Holders in Central Imenti Sub county

To assess the extent of adoption of greenhouse farming by small holders in Central Imenti, it was found very important to interview the respondents on their involvement in greenhouse farming since the study was on a fact finding mission to establish the factors which influence the small holders to adopt greenhouse farming. The respondents were asked to indicate whether they were trained on greenhouse farming and whether they were practicing greenhouse farming. Table 4.5 and Table 4.11 captures the findings from the study.

Table 4.5: Adoption of Greenhouse Farming

Adoption of greenhouse farming	Frequency	Percent (%)
Not Practicing	211	58
Practicing	153	42
Total	**364**	**100**

Source: Field data (2020)

The findings captured on the table above reflected that majority of the respondents 58% were not practicing greenhouse farming while a minority of the respondents 42% had ventured into the technology and still practicing. Based on these findings it clearly indicated that the level of adoption of greenhouse farming technology in Central Imenti Sub County was still low. The low adoption rates on greenhouse farming is associated with low monthly income levels by some farmers who term the venture as being too expensive citing the High initial installation costs. Some of the respondents also confirmed the fear of losing the benefits coming from farming using the conventional methods. Some of the benefits highlighted by the respondents included mixed farming which generates different crops in one season for the small holder farmer.

In reference to Table 4.11 the respondents were asked to state if they were trained in greenhouse farming. The findings revealed that 28% of the respondents who were trained in greenhouse farming and equipped with technical skills had adopted greenhouse farming while 72% of the respondents who were not trained had not adopted the technology or the quit the venture after trying. The training of the small holder farmers in greenhouse farming which is a specialized technology is likely to have boosted their knowledge and skills motivating them to adopt the technology while the lack of training could have limited the small holder farmers from trying the new technology.

4.5 Factors Influencing Adoption of Greenhouse Farming by Smallholders

The study aimed at profiling the factors that influence the smallholder farmers in Central Imenti to adopt greenhouse farming. On this the technical knowledge/skills on greenhouse farming, access to technical experts and the availability of resources like monthly income, land, water and labour were evaluated. The results are captured below:

4.5.1 Source of Income in Relation to the Adoption of Greenhouse Farming

The study investigated on the small holder farmers' source of income. The results are captured on Table 4.6.

Table 4.6: Source of Income of Farmers

Statement	Frequency	Percentage (%)
What is your occupation? Farming	229	63
Employed	49	13
Other sources of income	86	24
Total	**364**	**100**

Source: Field data 2020

From the table above 24 % of the farmers confirmed that they have other sources of income while 13% were also employed. However, the majority of the respondents at 63% were fully engaged in farming. The respondents confirmed of their engagement in other income generating activities or employed which concurs with the findings by Doss (2006) which suggested that off farm income may induce adoption of improved technologies although efficiency gains from adopting may be undermined by the limited time that the famers with off farm income sources allocated to the farming initiative. The small scale greenhouse farmers with other sources of income are therefore in constant struggle to strike a balance between their farming venture and other sources of income.

4.5.2 Monthly Income Levels of Farmers

The study investigated on the impact of income levels on the adoption of greenhouse farming by the small holder farmers. The study inquired how much the respondents earned per month. The findings were captured on Table 4.7.

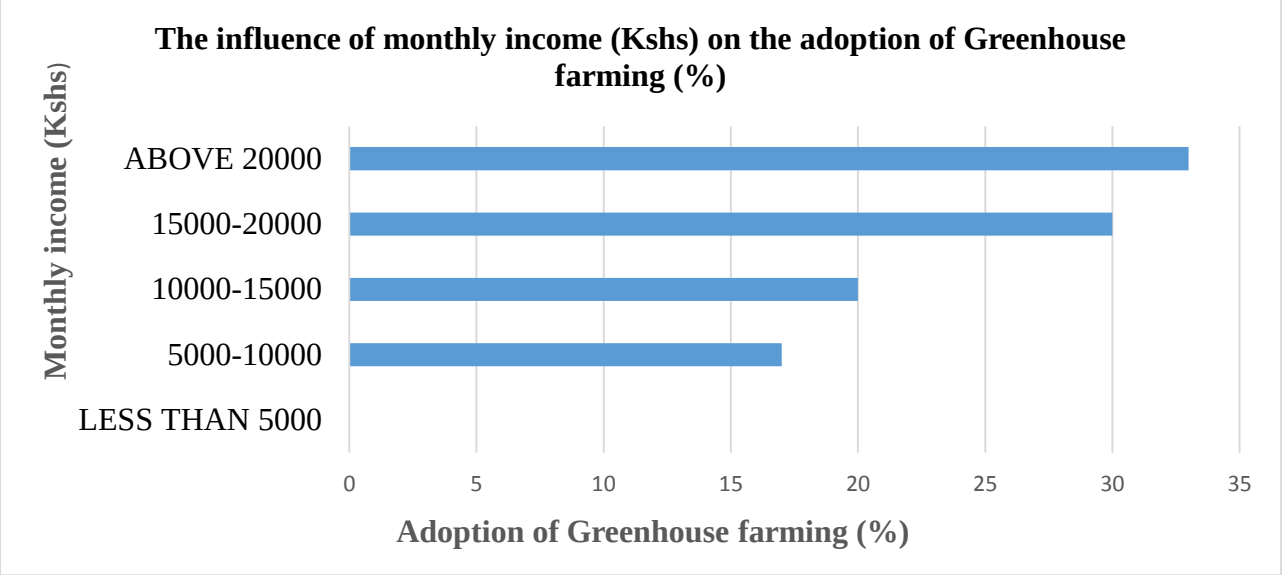
Table 4.7: Monthly Income Levels of Farmers

Statement	Income (Kshs)	Frequency	Percentage (%)
How much do you earn per month?	Less than 5000	None	0
	5001-10000	62	17
	10001-15000	73	20
	15001-20000	109	30
	Above 20000	120	33
Total		**364**	**100**

Source: Field data (2020)

From Table 4.7 it was observed that no respondent earned less than 5000 Kshs, 17% of the respondents earned between 5000 Kshs and 10,000 Kshs, 20% earned between 10,000 and 15,000 Kshs, 30% earned between 15,000 and 20, 000 Kshs while 33% earned above 20,000 Kshs. It was confirmed that most of the respondents who earned above 20, 000 were still practicing greenhouse farming in the area while most of the respondents who earned less had abandoned the venture. This indicated that failure to make profits is likely to have dampened the expectations from the small scale farmers who adopted the expensive technology aiming at its profitability. Most of the Small holder farmers adopt greenhouse house farming for self-food sufficiency and to earn proceeds from the sale of the surplus hence an amount above what was invested motivates these farmers.

Following the interviewing of the Key experts in the study area it was revealed that the construction cost of greenhouses was between Kshs 150,000 and 199,999. The installation cost of irrigation systems was indicated to be between Kshs 60,000 and 79,999. On the other hand, the cost of pest control products, fertilizers and seed were indicated to be between Kshs 20,000 and 25,000. These prohibitive costs of construction and maintenance are assumed to be one of the reasons why many small holder farmers had not adopted greenhouse farming in the study area and the country in general. This concurs with the findings highlighted by the Organic farmer (2011) that the obvious disadvantage of greenhouses is the prohibitive cost which is unaffordable to many small holder Kenyan farmers whose incomes are low



Source: Field data (2020)

Figure 4.1: Monthly Income of the Farmers

4.5.3 Availability of Resources and Adoption of Greenhouse Farming

The study evaluated on whether availability of resources impacted on the adoption of greenhouse farming. The respondents were asked to state if they termed the investment as affordable to the small holder farmers. The respondents were asked to mention if lack of resources limited the small holder farmers from adopting greenhouse farming. The results from the study are presented in Table 4.8.

Table 4.8: Availability of Resources and Adoption of Greenhouse Farming

Statement	**Yes**	**No**	**Percentage (%)**
Are greenhouses affordable to small holder farmers?	29	335	Yes 8 No 92
Does lack of resources limit the Small holder farmers from adopting greenhouse farming?	288	76	Yes 79 No 21
Total	**364**	**364**	**100**

Source: Field data (2020)

About 92% of the respondents admitted that greenhouses were not affordable for small holder farmers while 79% of the respondents confirmed that small holder farmers are limited by lack of resources leading to failure to adopt greenhouse farming. Only 8% who responded that greenhouses were affordable to the small holder farmers while 21% responded that small holder farmers are not limited by lack of resources indicating that there were other factors that limited the small holder farmers in Central Imenti from adopting greenhouse farming. The Literature review revealed that the average cost of a greenhouse ranges between 150,000 Kshs and 200,000 Kshs including the cost of seeds, pest control products and installation of drip irrigation. The average monthly income of the respondents interviewed (Table 4.7) range between 5,000 and 50,000. From the responses given by the respondents on this table it was clear that greenhouses are not affordable to most of the small holder farmers.

Further interaction with the respondents who confirmed that greenhouses are not affordable to the small holder farmers revealed that the investment towards greenhouse farming is huge and expensive for small holder farmers to afford which ultimately leads to low adoption levels. This is in agreement with the findings from the study done by Deininger and Okidi (1999) who found and documented that adoption of technologies is capital intensive and only affordable to the wealthy farmers hence adoption of new technologies is limited to the rich farmers who can afford. This indicates that adoption of any new technology is dependent on the cost and whether the farmers have the required financial resources needed to adopt the technology.

Plate no. 4.2 One of the respondents displaying his source of water used for the greenhouse farming. **Source: Field data, 2020 Captured on 28th February, 2020.**

4.5.4 Financial Support towards Adoption of Greenhouse Farming by Small Holder Farmers

The study investigated on the impact of financial support towards the adoption of greenhouse farming by small holder farmers. To determine this the study inquired on how the small holder farmers funded their greenhouses. Table 4.9 summarizes the findings from the study.

Table 4.9: Financial Support Towards Adoption of Greenhouse Farming

Statement	Own income	Government sponsored	Group initiative	Other sources	Total
How did you acquire your greenhouse?	36	95	215	18	**364**
Percentage %	**10**	**26**	**59**	**5**	**100**

Source: Field data (2020)

It was noted that 10% of the respondents used their own income to acquire their greenhouses while 26% received government sponsored greenhouses. About 59% of the respondents acquired their greenhouses as a group initiative while only 5% acquired their greenhouses through companies promoting farming products in the county.

It was observed that the farmers who used own income to sponsor the greenhouses and those who received their greenhouses through companies promoting farming products in the county were still productive while most of the government sponsored greenhouses were abandoned. There was no direct support offered to the small holder farmers from non-governmental organizations to support the adoption of greenhouse farming in the area under study.

Most of the small holder farmers in the area of study cited high interest rates on loans and lack of access to loans from credit institutions attributed to the high collateral requirement by lending institutions which is sadly lacking hence limiting the small holder farmers from accessing the loan or limiting the amount granted in relation to the amount required for one to adopt and remain sustainably in greenhouse farming. Some of the small holder farmers also

expressed their fear that taking a loan to invest in greenhouse farming may fail to generate the expected profitability.

These findings are in agreement with the findings by Deininger and Okidi (1999) stating that credit limits granted by formal lenders were relatively small in relation to what is required for one to invest in greenhouse farming recommending gradual increase on the loan granted for repeat borrowers.

4.5.5 Technical Support towards Adoption of Greenhouse Farming by Small Holder Farmers

The study sought to profile the impact of technical support towards adoption of greenhouse farming by small holder farmers. The respondents were asked how often they interacted with the extension officers. The findings were captured on Table 4.10.

Table 4.10: Extension Support towards Adoption of Greenhouse Farming by Small Holder Farmers

Statement	**None**	**Occasionally**	**Often**	**Total**
How often are you visited by the extension officers?	40	306	18	**364**
Percentage %	**11**	**84**	**5**	**100**

Source: Field data (2020)

From the table above 84 % of the respondents were occasionally visited, 5% were often visited by the extension officers while 11% were not visited at all. This indicated that extension service to the small holder greenhouse farmers is demand driven and not automatically available to all the small holder farmers. This is indicated by 11% of the farmers that were not visited at all. Most of the farmers disagreed with the statement that extension support was reliable and efficient to the small holder farmers. Further interaction with the Agriculture officers in the county revealed that there was only one Ward Agriculture officer serving the entire sub county hence it was impossible for him to cover the area adequately.

From these findings it was confirmed that the small holder farmers are not able to receive extension support because the available officers are few hence unreliable and not efficient. The private extension service is available in the area but expensive such that the small holder farmers cannot afford. This can be attributed to the few agriculture extension officers employed by the government and the demand driven approach used by the government in order for farmers to access extension service. The private extension service providers are few and equally expensive for the small holder farmers to afford.

These findings tally with the findings by Hussein et al (1995), who studied on the response by farmers to contact with extension support and documenting the close relationship between extension practice and its impact on technology adoption behavior from farmers. The study by Hussein examined the impact of training and visit system on the adoption of improved wheat technology concluding that the training and visit had improved the knowledge and adoption of the technology. It is very critical for the government to consider strengthening and realigning the extension provision system in order to respond to the needs of the small holder farmers.

4.5.6 Technical Skills and Adoption of Greenhouse Farming by Small Scale Farmers

The study pursued to evaluate the impact of technical skills on the adoption of greenhouse farming by small holder farmers. To profile the findings, the respondents were to indicate whether they were trained on greenhouse farming. The farmers were meant to give their response based on their access to technical training, farm demonstrations and education in relation to greenhouse farming technology. Table 4.11 captures the findings.

Table 4.11: Technical Skills and Adoption of Greenhouse Farming by Small Scale Farmers

Statement	Response	Frequency	Percentage (%)
Have you been trained in greenhouse farming?	No	262	72
	Yes	102	28
Total		**364**	**100**

Source: Field data 2020

From the table above 72% of the respondents were not trained while only 28% of the respondents were trained in greenhouse farming. This can be attributed to lack of agriculture

training institutions specializing in greenhouse farming in the study area and the expensive cost for the training which most of the small holder farmers cannot afford. These findings are supported by Braun (2011) after conducting a pilot farmer field school program on potato integrated pest management practices in Peru realizing that farmers who joined the program were more knowledgeable on IPM than the farmers who did not enroll. From the interview of the Technical experts operating in the area, it was apparent that most of the small holder farmers cannot afford the technical training.

Further evaluation of the study findings revealed that most of the farmers who were trained and equipped with technical skills had adopted greenhouse farming. Most of the respondents who were not trained had not adopted the technology or the quit the venture after trying. From the study findings captured under Table 4.11 it was noted that only 28 % of the respondents were trained on greenhouse farming. This boosted their technical skills motivating them to adopt greenhouse farming. The government should consider investing in farmer field schools where farmers can share and receive knowledge and demonstrations on farming. The government can also support the small holder farmers by establishing agriculture training centers equipped with qualified technical staff which adequately addresses the need by small holder farmers for technical knowledge in farming.

Further interaction with the respondents who had practiced greenhouse farming confirmed that 20% of the respondents had been farming for one year, 24% for two years, 22% for three years, 26% for four years and 8% for more than five years. From an evaluation of these responses it was confirmed that the longer the farmer has been practicing greenhouse farming the more experienced they were hence most of those still practicing greenhouse farming had been doing it for several years with persistence. Based on the responses captured on the table above it was evident that training small holder farmers on the management of greenhouses was likely to increase the adoption rates.

4.5.7 Education and Adoption of Greenhouse Farming by Small Holder Farmers

To document the impact of education on the adoption of greenhouse farming by small holder farmers in Central Imenti Sub County, the respondent's reactions on their level of education captured on Table 4.4 were reviewed**.** None of the respondents has not been to school, 27% attended primary school, 62% attended secondary school while 11% attended school up to the college/university/other trainings level.

Further evaluation of the study findings revealed that 42 % of the respondents who were practicing greenhouse farming had all been to school. This clearly indicated that the level of education for smallholder farmers has a positive and significant influence on the adoption of new technologies. Higher education elevates the farmer's attitude and thoughts making them more open and rational thereby better and willing to analyze the benefits from a new technology. Education enables farmers to be rational in decision making on the technology they chose to pursue based on the benefits observed. This makes the introduction and adoption of a new innovation easier.

4.5.8 Availability of Land and Adoption of Greenhouse Farming

The study interviewed the respondents seeking to profile on how availability of land affected on the adoption of greenhouse farming. The respondents were asked to state the size of land they own or access for their use for greenhouse farming. The findings were captured under Table 4.12.

Table 4.12: Availability of Land and Adoption of Greenhouse Farming

Statement	Response	Frequency	Percentage (%)
What's the size of land do you own?	Less than 1 acre	95	26
	1 to 2 Acres	175	48
	3 to 4 acres	54	15
	5 and above	40	11
What is the size of your greenhouse?	8M by 15M	284	78
	15M by 30M	51	14
	8M by 30M	29	8
	Others	None	0
Total		**364**	**100**

Source: Field data (2020)

According to the study findings captured in Table 4.12. 26% of the respondents held a land size of less than 1 acre, 48% of the respondents held 1-2 Acres, 15% 3-4 acres while only 11 % had more than 5 acres of land indicating that the expansion space to venture into greenhouse farming was limited. This was based on the observation made on the area of study where mixed farming was practiced hence greenhouse farming was not the only venture done by the respondents.

The main cause for the small parcels of land was increased population in the study area which led to land subdivision among the main beneficiaries of the family land. According to Anderson (2007) scarcity of land which is an economic resource limits agricultural production among small holder farmers. However, some of the farmers have resulted to innovative approaches for optimization of production using the small portions of land by adopting mixed greenhouse cropping and group greenhouse farming as observed on the area of study.

The study also revealed that the main source of land for the small holder farmers on the area of study was through family inheritance. Buying and leasing of land was noted to be the least practiced method used to obtain farming land by the small holder greenhouse farmers in the area. The companies promoting greenhouses in the area had constructed 8x15M greenhouses and 78% of the respondents had adopted that size of greenhouse in their farms while 14% had adopted 15M by 30M greenhouse and 8% had adopted 8M by 30M greenhouse. Majority of the farmers had only one greenhouse in their farms.

According to Riches (1999), a bigger greenhouse leads to more production of produce and better returns. However, the construction cost of the greenhouse varies with its size. And the size of greenhouse adopted by the farmers is based on its affordability. Based on this it's clear that there is more potential that has not been explored by the respondents in the study area hence the government to consider supporting the small holders by availing financial support in order for the farmers to acquire bigger greenhouses which guarantees on more profitability and increased output to boost on food security for the residents and income after sale of the surplus.

Plate no. 4.3 The type of greenhouses adopted by the small holder farmers. **Source: Field data, 2020 Captured on 25th February, 2020.**

4.6 Approaches Optimized by the Smallholders to Overcome the Constraints to Adoption of Greenhouse Farming

4.6.1 Diversification in Crops Grown in the Greenhouses and Adoption of Greenhouse Farming

The study interrogated the respondents seeking to know the types of crops grown in their greenhouses. The respondents were asked to state which crops they were growing and the findings captured under Table 4.13.

Table 4.13: Crops Diversification and Adoption of Greenhouse Farming

Statement	Response	Frequency	Percentage (%)
What crops are you growing in the greenhouse?	Tomatoes	255	70
	Capsicum	62	17
	Vegetables	45	12
	Fruits	2	1
	Others	None	0
Total		**364**	**100**

Source: Field data 2020

Plate no. 4.4 Crops grown by the small holder farmers **Source: Field data, 2020 Captured on 27th February, 2020.**

The study literature review revealed that a variety of crops could be grown under a greenhouse. However, Table 4.14 noted that 70% of the respondents in Central Imenti Sub County were growing tomatoes as the main crop believed to earn more income. 17% of the respondents had grown capsicum, 12% had grown vegetables and only 1% had attempted growing fruits while none grew other crops under their greenhouse. The small scale farmers in the study area have not explored the full potential of greenhouses as suggested by the works of Onder J. (2009) who indicated that the following crops would be cultivated in the greenhouses; sugarcane, sweet potatoes, Irish potatoes, onions, French beans, green bean, carrots, cucumber, and even bamboo seedlings. Diversification is dictated by market forces and ecological characteristics which indicated the need to create awareness to the small holder farmers on diversification to other crops for rotation to maintain the soil fertility and eliminate the risk of pest build up in the greenhouse. Overreliance on a single crop was evident in the study area leading to poor performance and low yields.

4.6.2 Group Farming and Adoption of Greenhouse Farming

The study interviewed the respondents seeking to document the efforts being put by the small holder farmers in Central Imenti to sustainably farm under greenhouse. The respondents were asked to mention how they acquired their greenhouse in order to get into greenhouse farming. Based on the findings captured under Table 4.9 it was noted that 59% of the respondents had adopted the greenhouse farming venture under a group arrangement. This was mainly youth groups and women groups who lacked ownership of resources like Land and water. From the respondents it was gathered that group work arrangement provides cheap labour to manage the

greenhouse project leading to farming costs reduction, better yields and marketing of the produce. It was confirmed that most of the greenhouses being operated under groups were in operation while some of the greenhouses operated by individual owners were abandoned. The interviewed technical experts confirmed it was easier to reach out to farmer groups to share information on greenhouse farming than it was to reach out to individual farmers. The interviewed group farmers revealed that they were making efforts to diversify into other crops like herbs, capsicum and strawberry as well as online marketing of their produce thereby leading to better profitability after adoption of the group greenhouse farming. This is in agreement with the findings that Organizing Farmers into groups helps them to consolidate their efforts to address their problems communally through forums and enables them access information, markets and negotiate for best prices for their products and cheaper prices for farm inputs (Kenmore & Halwart, 1998).

4.7 Hypothesis Testing

The study sought to determine the influence of technical skills on the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County. To achieve this, the following null hypothesis was tested;

> *$H0_1$: There is no significant relationship between technical skills and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County*

To test **$H0_1$**, a Chi-square test was conducted. Training on greenhouse farming was cross tabulated against practicing greenhouse farming and the findings are provided in Table 4.14. The findings show that Chi-square statistic **(χ^2)** of 102.756a, p =0.000 were computed. Given that the computed p value was less than 0.05, it was inferred that training on greenhouse farming and practicing greenhouse farming by the smallholder farmers in the study area were significantly related. It is on this basis that the null hypothesis that there is no significant relationship between technical skills and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County was rejected. It was therefore, concluded that technical skills and adoption of greenhouse farming among smallholder farmers in the study areas were significantly related. These findings concurred with that of Adebiyi and Okunlola (2011) that education and training motivated a farmer in setting the pace by being an early adopter of innovation while shaping the extent to which the new innovation is applied. The findings also agree with the assertions of Kwadwo (2009) that

the pathway leading to agricultural productivity involved building the capacity of the smallholder farmers to innovate while adopting new technologies.

Table 4.14: Cross tabulation Analysis between Technical Skills and Adoption of Greenhouse Farming

		Are you practicing greenhouse farming?				
		No	Yes	Total		
		n; (%)	n; (%)	n; (%)	χ^2	p value
Are you trained in greenhouse farming?	No	102; 100.00	0; 0.00	102; 28	102.756a	0.000
	Yes	109; 41.60	153; 58.40	262; 72		
Total		**211; 58.00**	**153; 42.00**	**364; 100.0**		

The study also determined whether the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County was influenced by the support given by agricultural extension officers. The following null hypothesis was thus formulated and tested;

> ***$H0_2$:*** *There is no significant relationship between agricultural extension support and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County*

Chi square test results were obtained after conducting a cross tabulation analysis between how often the farmers interacted with the agricultural extension officers and practicing greenhouse farming. As shown in Table 4.15, Chi-square statistic (χ^2) was 24.191a and the associated p= value was 0.000. These findings meant that these two variables were significantly related given that the p value that was obtained was less than 0.05. The null hypothesis was therefore rejected and an inference made that there is a significant relationship between agricultural extension support and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County. These findings agree with the views of Swanson (2008) that people especially in rural areas get persuaded into adopting improved methods of farming for improved crop and livestock productivity through agriculture extension service. The findings also support the observation by KEPHIS (2017) the ability of farmers to embrace innovation is based on their access to sources of information and knowledge and hence, agricultural

extension addresses the immediate needs of the small holder farmers facilitating their change of livelihood and production system.

Table 4.15: Cross tabulation Analysis between Agricultural Extension Support and Adoption of Greenhouse Farming

		Are you practicing greenhouse farming				
		No	**Yes**	**Total**		**p**
		n; (%)	**n; (%)**	**n; (%)**	**χ^2**	**value**
How often do you interact with the agriculture extension officers?	Often	2; 11.10	16; 88.90	18; 5.00	24.191a	0.000
	Occasionally	177; 57.80	129; 42.20	306; 84.00		
	Never	32; 80.00	8; 20.00	40; 11.00		
Total		**211; 58.00**	**153; 42.00**	**364; 100.0**		

The study further sought to establish whether the availability of resources influenced the adoption of greenhouse farming by smallholder farmers in the study area. The study tested the following null hypothesis;

> ***$H0_3$:*** *There is no significant relationship between availability of resources and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County*

The findings presented in Table 4.16 reveal that there was a significant relationship between affordability of greenhouses to smallholder farmers and them practicing greenhouse farming as supported by (χ^2=43.456a, p= 0.000). The findings also show that the level of income earned per month and greenhouse farming among the smallholder farmers in Central Imenti Sub County were significantly related as shown by (χ^2=18.283a, p= 0.000). The study further found that there was a significant relationship between reliable water and availability of land and the greenhouse farming among the small holder farmers in the study area given (χ^2=8.393a, p= 0.004) and (χ^2=42.948a, p= 0.000) respectively. From these findings on the different measures of availability of resources, the p value computed were less than 0.05 and this led to the rejection of the null hypothesis that there is no significant relationship between availability of resources and the adoption of greenhouse farming by the smallholder farmers in Central Imenti Sub County in Meru County. The findings support those by El Oster and Morehart (1999) who

found and documented that adoption of technologies is capital intensive and only affordable to the wealthy farmers hence adoption of new technologies is limited to the rich farmers who can afford. The findings also are consistent with the findings of Doss (2006) that as the size of land owned increases, farmers rate of adoption of new farming technologies increases and that farmers faced with water constraints are less likely to adopt new technologies like greenhouse farming where sufficient water is a necessity.

Table 4.16: Cross tabulation Analysis between Agricultural Extension Support and Adoption of Greenhouse Farming

		Are you practicing greenhouse farming?				
		No	**Yes**	**Total**		**p**
		n; (%)	**n; (%)**	**n; (%)**	**χ^2**	**value**
Are greenhouses affordable to small holder farmers?	No	211; 63.00	124; 37.00	335; 92.03	43.456a	0.000
	Yes	0; 0.00	29; 100.00	29; 7.97		
	Total	**211; 58.00**	**153; 42.00**	**364; 100.0**		
How much do you earn per month?	Less than 5000Ksh	49; 79.00	13; 21.00	62; 17.03	18.283a	0.000
	5001-10000Ksh	47; 64.40	26; 35.60	73; 20.05		
	10001-15000Ksh	56; 51.40	53; 48.60	109; 29.95		
	15001-20000Ksh	59; 49.20	61; 50.80	120; 32.97		
	Total	**211; 58.00**	**153; 42.00**	**364; 100.0**		
Do you have reliable water for greenhouse farming?	No	41; 75.90	13; 24.10	54; 14.84	8.393a	0.004
	Yes	170; 54.80	140; 45.20	310; 85.16		
	Total	**211; 58.00**	**153; 42.00**	**364; 100.0**		
What is the size of your farm?	1-2 Acres	120; 68.60	55; 31.40	175; 48.08	42.948a	0.000
	Less than 1 acre	63; 66.30	32; 33.70	95; 26.10		
	3-4 acres	19; 35.20	35; 64.80	54; 14.84		
	Above 4 Acres	9; 22.50	31; 77.50	40; 10.98		
	Total	**211; 58.00**	**153; 42.00**	**364; 100.0**		

4.8 Summary of the Chapter

This chapter discussed on the results from the study. It highlighted on the response rate, the demographic characteristics of the respondents, the gender and age of the respondents, the extent of adoption of greenhouse farming by the small holder farmers in Central Imenti Sub county, the factors influencing the adoption of greenhouse farming by the small holder farmers in Central Imenti Sub county and the approaches optimized by the small holder farmers in Central Imenti to overcome the constraints to adoption of the technology. The chapter concluded by discussing the results based on the three study objectives as highlighted by the subtopics identified.

CHAPTER FIVE: SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This is the chapter containing a summary of the study. It highlights the findings of the study, captures the conclusion, recommendations and suggestions for further research. The conclusions presented on this section were guided by the study objectives, informed by the study findings, data analysis, interpretation and discussion of the topic being studied. The suggestions for further research were identified and captured at the end of this chapter.

5.2 Summary of the Findings

This section contains a summary of the main findings of the study:

5.2.1 Adoption of Greenhouse Farming by Small Holder Farmers in Central Imenti Sub County

The results indicated that the majority of the small holder farmers in Central Imenti Sub County at 58% had never practiced greenhouse farming while the minority at 42% were practicing greenhouse farming.

5.2.2 Factors Influencing Adoption of Greenhouse Farming by Smallholder Farmers in Central Imenti Sub County

This specific objective of the study aimed at profiling the factors that influence the small holder farmers in Central Imenti to adopt greenhouse farming. The indicators assessed included availability of resources like Land, water, farm labour, access to financial support, access to extension support/technical experts, farmers' experience, education and income levels.

About 24% of the respondents confirmed that they had other sources of income while 13% of the respondents confirmed they were employed clearly indicating that access to finances was a major factor that influenced on the adoption of greenhouse farming and that not all small holder farmers relied on farm income to fund greenhouse farming. This is in agreement with the findings by Doss (2006) who discovered that off farm income facilitates farmers in adopting new technologies. About 33 % of the respondents confirmed that they earned above 20, 000 Kshs per month followed by 30 % of the respondents who indicated they earned between 15,000 and 20,000 Kshs per month which clearly indicated that the income level of the farmer influenced on the adoption of greenhouse farming. 17 % of the respondents earning between

5000 and 10,000 Kshs per month confirmed that their low level of income was their greatest hindrance to the adoption of greenhouse farming.

The results following the interview of the technical experts in the area of study revealed that the cost of installation of greenhouses, maintenance, cost of seeds, fertilizers and pest control products totaled between 150, 000 and 250,000 Kshs. This indicated that adoption of the greenhouse farming initiative was expensive requiring huge investment which is not affordable to the small holder farmers with low monthly income or relying fully on the farm income. This partly informs why about 58% of the respondents in the study area had not adopted greenhouse farming and supported by the confirmation by 92 % of the respondents who indicated that greenhouses were not affordable to the small holder farmers and a further 79% of the respondents who indicated that small holder farmers were limited by lack of resources hence they would adopt greenhouse farming if they received financial support.

About 84 % of the respondents were occasionally visited by the agriculture extension officers followed by 5 % of the respondents who were often visited and confirmed that access technical expertise improved their knowledge on greenhouse farming. A minority of the respondents at 11 % were not visited at all by the extension officers which highlighted the demand driven nature of the service offered to the farmers. This indicated that access to extension support influences the adoption of greenhouse farming by small holder farmers.

About 42 % of the respondents were engaged in greenhouse farming. The respondents had different education levels some with university/college education others with secondary education and primary education while none had no education at all. This finding confirms that education influences the adoption of greenhouse farming. Further interaction with these respondents revealed that most had been in greenhouse farming for more than one year confirming that more experience with the technology promoted the ability to sustainably remain in greenhouse farming. This concurs with the findings by Parry M. et al (2009) which suggested that unleashing the potential of farmers reduces hunger and creates a more resilient global food supply for everyone.

5.2.3 Approaches Optimized by the Smallholders in Central Imenti Sub County to Overcome the Constraints to Adoption of Greenhouse Farming

This specific objective of the study aimed at identifying the approaches optimized by the small holder farmers in Central Imenti in order to overcome the constraints faced in adopting greenhouse farming. The results indicated that the small holders in Central Imenti Sub county

mainly the youth and women optimized in group greenhouse farming, online marketing of their produce and crops diversification in order to overcome constraints like low income, lack of land, lack of farm labour, lack of water and inadequate marketing of their produce.

This was indicated by 59 % of the respondents who confirmed that they acquired their greenhouse, were farming and marketing their produce online as a group initiative. 20 % of these respondents confirmed that they were pursuing crop diversification. This had been achieved by doing crops like capsicum (7 %) and vegetables (12 %) and Fruits (1%) under greenhouse instead of relying fully on tomatoes as the main crop which resulted to build up on pests and diseases. This confirms the work of Anderson (2007) which suggested that in order for a farmer to recover from the huge investments in high valued crops, marketing skills of produce was a most crucial component.

It was observed that the group farmers had invested in organic greenhouse farming where they used ash, tobacco leaves, neem and pepper extracts to spray to the crops instead of using pest control products thereby making their produce preferred by their customers in the interest of food safety. The respondents indicated to have knowledge on how to manage their greenhouses including when to open the side openings and when to close to regulate on the temperature. The respondents confirmed having acquired greenhouse maintenance and management training as indicated by the 5% of the respondents who acquired their greenhouses through the greenhouse construction companies promoting their products in the area of study. This also highlighted on the fact that greenhouse construction companies have been in the forefront in advocating for the adoption of this farming technology as opposed to being a government led project.

This is also supported by the literature review on the work done by Anderson (2007) documenting that farmers require skills on construction and maintenance of greenhouses, farming and marketing.

5.3 Conclusion

Based on the findings from the study several conclusions were done:

1. The adoption of greenhouse farming by small holders in Central Imenti Sub county was Low compared to the neighboring sub counties. The performance of the crops cultivated in the greenhouses clearly indicated that the huge investment in greenhouse farming could be recovered within a short period of time with consistency assuring on throughout the year crop production for food security.

2. The high cost of greenhouse construction and maintenance is a major limitation to the adoption and expansion of greenhouse farming by small holder farmers despite the potential return on investment that this specialized technology possess. Access to credit, financial support and interaction with technical experts directly influenced on the adoption of greenhouse farming by the small holder farmers in central Imenti Sub County.
3. The small holder farmers in the area of study optimized in group greenhouse farming and mixed cropping in order to overcome the challenges of land, high costs and farm labour facing the adoption of greenhouse farming.

5.4 Policy Recommendations

From the findings captured, the study recommends the following: -

1. The study recommends to the ministry of Agriculture through the county government to strengthen extension service provision since technical experts serve as the link between information and the small holder farmers. Enhanced knowledge, skills and experience on greenhouse farming will promote the adoption and performance of greenhouses once adopted by the small holder farmers. Awareness creation can be done through seminars, workshops, trainings, farm demonstrations and stakeholder forums to enhance the knowledge available to these farmers on greenhouse farming.
2. There is need to boost small holder famers financial capital by making credit facilities services available to them. The credit institutions to consider coming up with small holder loan facilities tailored to suit their needs especially on low interest's rates and extended repayment period to allow the small holder farmers to repay after selling their produce.
3. The small holder farmers need to organize themselves into groups facilitating credit access, easier access of the demand driven extension service, bargain for best prices on farm inputs and their greenhouse produce when marketing them. The small holder farmers to consider using local materials to make improvised greenhouses which cuts on the cost of farming using greenhouse technology.

5.5 Research Recommendations

Several significant gaps arose from this area of study which needs to be addressed in order to promote the adoption of greenhouse farming. This study recommends further research on:

1. Factors influencing the adoption of greenhouse farming by small holder farmers in other counties for regional generalization of the findings.
2. The influence from use of traditional methods of farming on the adoption of alternative farming methods.

REFERENCES

Anderson, J. R. (2007). Agricultural advisory services: Background paper for the World Development Report 2008. World Bank, Washington, DC.

Braun, A., & Duveskog, D. (2011). The farmer field school approach: History, global assessment and success stories. Background paper for the IFAD Rural poverty report.

Beibel, J. P. (1960). Hydroponics-The Science of Growing Crops without Soil. Florida Department of Agric. Bull, 180.

County, M. (2014). The Report Meru County 2014, Kenya.

Dwasi, C. O. (2017). Factors influencing adoption of greenhouse farming technology among small scale horticulture farmers in Gem Sub-county, Kenya (Doctoral dissertation, University of Nairobi).

Doss, C. R. (2006). Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agricultural economics, 34(3), 207-219.

De Vleeschouwer, O. (2001). Greenhouses and conservatories. Flammarion.

Deininger, K., & Okidi, J. (1999). Capital market access, factor demand, and agricultural development in rural areas of developing countries: The case of Uganda. EPRC Research Series No, 12.

Friedmann, H., & Allen, P. (1993). Food for the Future: Conditions and Contradictions of Sustainability. Edited by P. Allen. John Wiley and Sons, New York, 213-233.

Gopalan, C. (2001). Achieving household nutrition security in societies in transition: An overview. Asia pacific journal of clinical nutrition, 10, S4-S12.

HCDA, & (Horticultural Crop Development Authority). (2008). Horticulture data 2005–2007 validation report.

Hussain, S. S., & Byerlee, D. R. (1995). Education and farm productivity in post-'green revolution' agriculture in Asia (No. 998-2016-78007).

Horstkotte, G., Lightfoot, C., Waibel, H., & Kenmore, P. (1998). Integrated pest management and aquatic life management: a natural partnership for rice farmers.

Janick, J. (1986). Horticultural science. Macmillan.

Jamison, D. T., & Lau, L. J. (1982). Farmer education and farm efficiency. Johns Hopkins University Press.

Kurgat, K. E. (2013). Influence of greenhouse farming on food security: a case of Eldoret east sub-county, Kenya (Doctoral dissertation, University of Nairobi).

Kacira, M. (2011, September). Greenhouse production in US: status, challenges, and opportunities. In CIGR 2011 conference on Sustainable Bioproduction WEF (pp. 19-23).

Kamau, P., & Baumgartner, P. (2011). The organic farmer. The Magazine for Sustainable Agriculture in Kenya, 1.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and psychological measurement, 30(3), 607-610.

Liu, G. Q., Nyalala, S. P. O., Nyanjage, M. O., & Tuitoek, D. K. (2005). Greenhouse management.

Liu, G. Q., & Nyalala, S. P. O. (2017). Greenhouse tomato production, Do it yourself manual.

Liu, G., & Nyalala, S. P. O. (2017). Greenhouse tomato production Egerton University Press Njoro Kenya.

Mwendia, A. S. (2019). An Investigation of the Drivers of Diversification to Banana Farming Among Households in Meru County, Kenya (Doctoral Dissertation, Kenyatta University).

Muthuri, J. S. (2016). Effects of Farm Technologies on Sweet Potato Production in Manyatta Sub County, Embu County (Doctoral dissertation, University of Nairobi).

Mutuma, L. W. (2012). Factors influencing adoption of greenhouse horticultural farming in Mirigamieru East Division, Imenti North District (Doctoral dissertation, University of Nairobi, Kenya).

MoA, H. C. D. (2012). Horticultural Crops Production Report 2010. HCDA, MoA, Nairobi, Kenya.

Maharana, L., & Koul, D. N. (2011). The Emergence of Hydroponics. Yojana (June), 55, 39-40.

Mugenda, O. M., & Mugenda, A. G. (2003). Research methods: Quantitative and qualitative approaches. Acts press.

Muturi, S. N. (1999). Agroforestry Extension Manuals: A survey of their use in Kenya.

NAFIS, N. (2014). National Farmers Information Service.

National Agriculture and Livestock Extension Programme NALEP2 (2011). Extension packages for crop production, Nairobi, Kenya. Pages 7-18

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T... & Magalhaes, M. (2009). Climate change: Impact on agriculture and costs of adaptation (Vol. 21). Intl Food Policy Res Inst.

Nyariki D.M, (2007) Kenya Position Paper on the Horn of Africa Initiative on Tackling Food Insecurity, Pg 2-9.

Nabbumba, R., & Bahiigwa, G. (2003). Agricultural Productivity constraints in Uganda: Implications for investment (No. 677-2016-46637).

Omoro, P. A. (2015). Assessing the extension staff farm visits frequency effect on greenhouse technology performance in small scale farms in Gusii highlands, Kenya. Open Access Library Journal, 2(02), 1.

Omoro, P. A. (2014). Assessment of Selected Factors Affecting Performance of Greenhouse Technology in Small Scale Farms in Gusii Highlands, Kenya (Doctoral dissertation, Kisii University).

Onder, D. (2009). Status of greenhouses in Eastern Mediterranean coastal areas of Turkey. African Journal of Biotechnology, 8(8).

Parry, M., Evans, A., Rosegrant, M. W., & Wheeler, T. (2009). Climate change and hunger: responding to the challenge. Intl Food Policy Res Inst.

Parry, M., Evans, A., Rosegrant, M. W., & Wheeler, T. (2009). Climate change and hunger. Responding to the challenge. World Food Programme, Rome.

Phillips, J. M., & Marble, R. P. (1986). Farmer education and efficiency: a frontier production function approach. Economics of Education Review, 5(3), 257-264.

Ross D.S. (2000); Components of a greenhouse, Department of Agricultural Engineering, University of Maryland Cooperative Extension Service.

Riches, G. (1999). Advancing the human right to food in Canada: Social policy and the politics of hunger, welfare, and food security. Agriculture and Human Values, 16(2), 203-211.

Rosenzweig, M. R. (1995). Why are there returns to schooling? The American Economic Review, 85(2), 153-158.

Swanson, B. E. (2010). Global review of good agricultural extension and advisory service practices.

Swanson, B. E. (2008). Global review of good agricultural extension and advisory service practices (p. 82). Rome: Food and Agriculture Organization of the United Nations.

Swanson, B. (2006). Improving agricultural extension. Daya Books.

The organic Farmer, (2011). The other side of greenhouses article no. 77, pg. 1&5. Published by International Centre of Insects Physiology and Ecology. Retrieved from http:/www.infonet biovision.org/ on 15/11/2017.

Zhou, Y. (2010). Smallholder agriculture, sustainability and the Syngenta Foundation. Syngenta Foundation for Sustainable Agriculture, 1-15.

APPENDICES

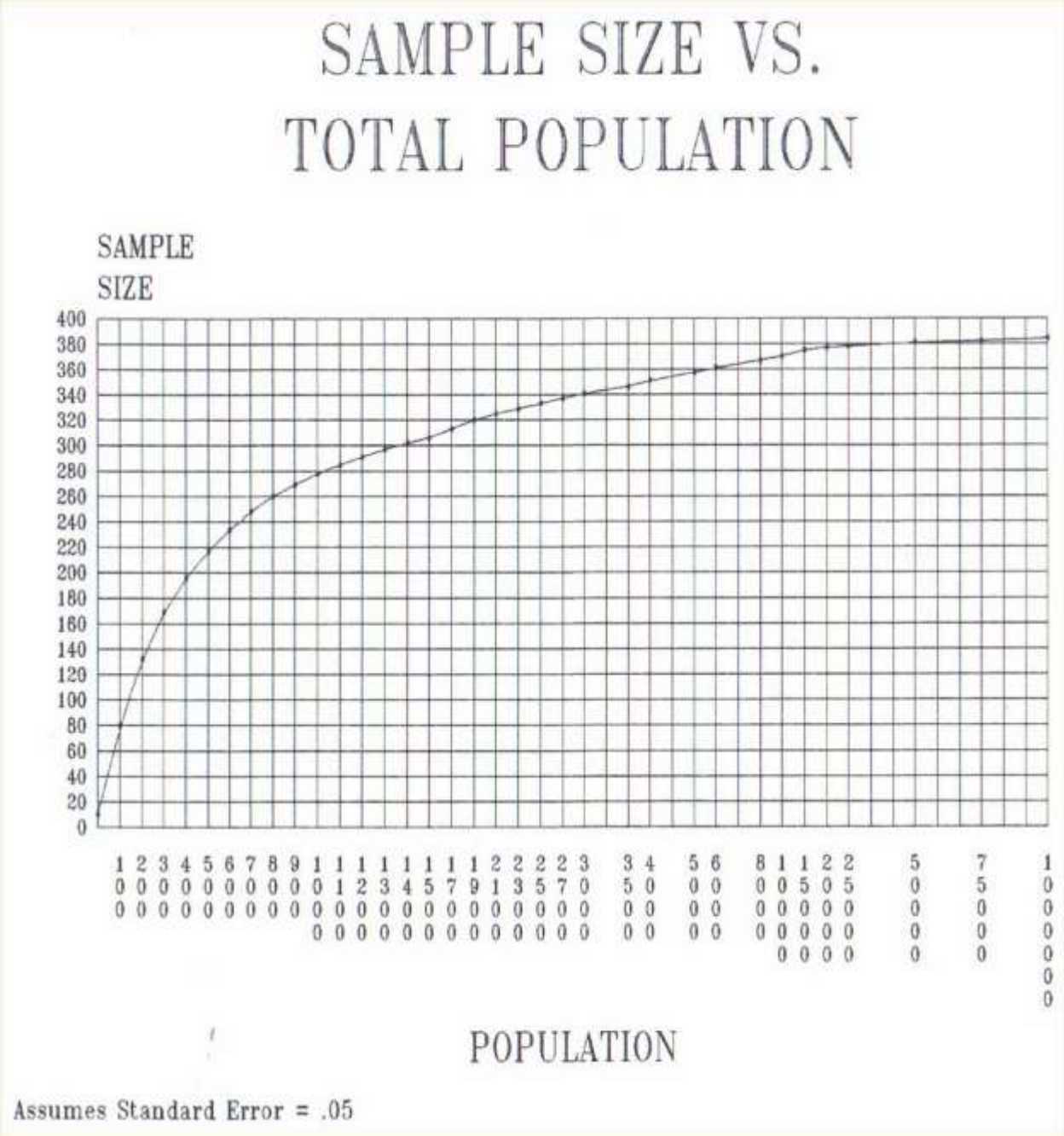
Appendix 1: Morgan's Table for Determining Sample Size

Source: Krejcie and Morgan (1970)

Populasi (N)	Sampel (n)	Populasi (N)	Sampel (n)	Populasi (N)	Sampel (n)
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Appendix 2: Morgan's Graph indicating Sample Size vs. Total population

Source: Krejcie and Morgan (1970)



Appendix 3: Greenhouse Farmers Questionnaire

FACTORS INFLUENCING ADOPTION OF GREENHOUSE FARMING BY SMALL HOLDER FARMERS IN CENTRAL IMENTI SUBCOUNTY, MERU COUNTY.

NOTE: The information will be treated with total confidentiality and will only be used for the purpose of the study. Kindly tick your response in the right box indicating down your comments on the provided space. For confidentiality you may skip indicating your name on the questionnaire.

Part A. GENERAL INFORMATION ON ADOPTION OF GREENHOUSE FARMING.

1. What is your Gender?

Male ( ) Female ( )

2. What is your Age?

Below 25 years ( )

25-35 years ( )

36-45 years ( )

46-55 years ( )

Above ( )

3. Are you practicing greenhouse farming?

Yes ( ) No ( )

4.In your own opinion what are the advantages of greenhouse farming?

……

……

5. In your own opinion what are the disadvantages of greenhouse farming?

……

……

6. What's the size of your greenhouse?

8M BY 15M

15M BY 30M

8M BY 30M

Others (specify) ----------

7. Who owns the greenhouse?

Individual ( )

Group ( )

Institution ( )

Others ( )

8. If you purchased the greenhouse, how did you acquire the Finances?

Savings ( )

Loan ( )

Relatives/friends donation ( )

Others (Specify)……..

9. Which crops do you grow in the greenhouse?

……

……

10. Are you trained in greenhouse farming?

Yes ( ) No ( )

11. What is your level of education?

Never been to school ( )

Primary education ( )

Secondary education ( )

College/university ( )

10. For how long have you been farming using a greenhouse?

One year ( )

Two years ( )

Three years ( )

Four years ( )

Five years and above ( )

SECTION B: FACTORS INFLUENCING THE ADOPTION OF GREENHOUSE FARMING.

11. What is your occupation?

Farmer ( )

Employed ( )

Other sources of income ( )

12. What is your income from greenhouse farming in the previous season?

Less than 5000Ksh ( )
5001-10000Ksh ( )
10001-15000Ksh ( )
15001-20000Ksh ( )
Above 20000 ( )

13. In your own opinion is greenhouse farming profitable?

Yes ( ) No ( )

14. Do you have reliable water for greenhouse farming?

Yes ( ) No ( )

15. What is the size of your farm?

Less than 1 acre ( )

1-2 Acres ( )

3-4 acres ( )

Above 4 Acres ( )

16. Does lack of resources hinder you from practicing greenhouse farming?

Yes ( ) NO ( )

17. Are you able to access credit facilities to adopt greenhouse farming? Would you take a loan to adopt greenhouse farming?

Yes ( ) No ( )

18. In your opinion what motivates/limits you towards adoption of greenhouse farming?

---

19. Are agriculture extension services accessible in your area? Do the extension officers support greenhouse farmers?

Yes ( ) No ( )

20. How often do you interact with the agriculture extension officers?

Very often ( ) Often ( ) Rarely ( ) Never ( )

21. Do you wait, visit or request the extension officers for support?

Wait ( ) Visit ( ) Request ( )

22. Lack of agriculture extension service has limited farmers from adopting greenhouse farming?

Strongly agree ( )

Agree ( )

Disagree ( )

Strongly disagree ( )

23. What is in your own opinion could be done to facilitate adoption of greenhouse farming?

……

……

……

SECTION C: WHAT ARE THE SMALL HOLDER FARMERS DOING TO FACILITATE ADOPTION OF GREENHOUSE FARMING?

24. Do you discuss challenges facing small holder greenhouse farmers?

Yes [ ] No [ ]

25. What are the small holder farmers doing to sustainably remain in greenhouse farming?

……
……
……

26. Are you aware of the government policies supporting greenhouse farming?

Yes [ ] No [ ]

27. Are the government policies friendly to the small holder greenhouse farmers?

Yes [ ] No [ ]

28. In your opinion how can the small holder farmers be motivated to adopt and sustainably remain in doing profitable greenhouse farming?

……
……
……

Appendix 4: Guide for Scheduled Interview for Technical Experts

1. For how long have you been serving farmers?
2. How many times do you contact with the farmers per month?
3. What benefits do farmers gain by practicing greenhouse farming?
4. Where do the farmers buy their greenhouses from?
5. What crops are farmers growing under greenhouse farming?
6. Is there market for greenhouse produce in the area?
7. What is the rate of adoption of greenhouse farming in the area?
8. Are there any technology gaps that need to be filled to serve greenhouse farmers well?
9. What are your recommendations that can promote the adoption and performance of small holder greenhouse farming?
10. What is the initial installation cost for a green house?
11. In your opinion do all farmers have the ability to pursue this kind of enterprise?
12. Do farmers have the necessary farming skills and greenhouse management training to run this kind of venture?
13. What marketing skills do small holder farmers have for crops grown under green house?
14. What other crops can be grown under a green house?
15. What are the challenges facing the small holder greenhouse farmers?

Appendix 5: The Letter of Transmittal

Dorcas Mugure Mugambi
P.O Box 5366-00200
Nairobi.

Dear Respondent,

Re: <u>REQUEST FOR PARTICIPATION IN ACADEMIC STUDY.</u>

I am a Postgraduate student at the University of Nairobi pursuing a Master of Arts Degree in Environmental Planning and Management. I am conducting an academic research on the **"FACTORS INFLUENCING THE ADOPTION OF GREEN HOUSE FARMING TECHNOLOGY BY SMALLHOLDER FARMERS IN CENTRAL IMENTI SUBCOUNTY IN MERU COUNTY"**

You have been chosen to participate in this study by filing this questionnaire to obtain information on greenhouse farming practiced by you individually. It is hoped that this study will reveal the gaps that are existing regarding the topic under study thereby contributing to the body of knowledge available.

Please provide accurate information and return the completed questionnaire to the researcher. The information you give for this study will be treated with utmost confidentiality and will be used for the purpose of this study only.

In case of any queries and clarification, contact the researcher using the contacts given below.

Thank you for your co-operation and precious time.

Yours faithfully,

Dorcas Mugambi
Email:dorcasmugambi@gmail.com
Phone:0720619222

Appendix 6: Letter of Authority from the University

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Telephone: +254 2 318262
Extension: 28016
Fax: +254 2 245566
Email-geography@uonbi.ac.ke

P.O. BOX 30197-00100
NAIROBI
KENYA

October 1st 2019

The Director,
National Commission for Science & Technology
Nairobi, Kenya.

Dear Sir/Madam,

RESEARCH PERMIT: DORCAS MUGAMBI M.

This is to confirm that the above named is a Master of Arts student (Registration Number – C50/5549/2017) at the Department of Geography and Environmental Studies, University of Nairobi registered.

Ms. Mugambi is currently undertaking research on a topic titled: **Factors influencing the adoption of Green Houses Farming by small holders in Central Imenti Sub-county Meru County.**

Any assistance accorded to her will be highly appreciated.

CHAIRMAN
Department Of Geography
and Environmental Studies
UNIVERSITY OF NAIROBI

Dr. Boniface Wambua
Chairman, Department of Geography & Environmental Studies

Appendix 7: Permit to Carry Out Research

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 129966

Date of Issue: 07/November/2019

RESEARCH LICENSE

This is to Certify that Ms. MUGAMBI DORCAS of University of Nairobi, has been licensed to conduct research in Meru on the topic: FACTORS INFLUENCING THE ADOPTION OF GREENHOUSE FARMING BY SMALLHOLDER FARMERS IN CENTRAL IMENTI SUB-COUNTY IN MERU COUNTY for the period ending: 07/November/2020.

License No: NACOSTI/P/19/2615

129966

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Turnitin Originality Report

Processed on: 2020년11월26일 20:13 EAT
ID: 1457701065
Word Count: 19400
Submitted: 1

FACTORS INFLUENCING THE ADOPTION OF GREENHOUSE FARMING BY SMALLHOLDERS IN CENTRAL IMENTI SUBCOUNTY IN MERU COUNTY.
By Dorcas Mugambi

26TH NOVEMBER 2020

Similarity Index	Similarity by Source
11%	Internet Sources: 8% Publications: 2% Student Papers: 5%

1% match (Internet from 05-Jul-2017)
http://file.scirp.org/Html/68064_68064.htm

1% match (Internet from 21-Mar-2014)
http://www.ieteas.scholarlinkresearch.org/articles/The%20Status%20of%20Greenhouses%20Utilization%20in%20Oyo%20State,%20Nigeria.pdf

< 1% match (student papers from 20-Jan-2017)
Submitted to Middlesex University on 2017-01-20

< 1% match (Internet from 07-Jun-2019)
http://www.starcsplus.com/documents/ta/cidp/Kenya%20CIDP%202013-17%20Review%20of%20Climate%20Change%20Mainstreaming.pdf

< 1% match (student papers from 28-Dec-2017)
Submitted to Africa Nazarene University on 2017-12-28

< 1% match (student papers from 16-Nov-2016)
Submitted to University of Nairobi on 2016-11-16

< 1% match (student papers from 29-Apr-2016)
Submitted to Midlands State University on 2016-04-29

< 1% match (student papers from 29-Jun-2020)
Submitted to Teachers' Colleges of Jamaica on 2020-06-29

< 1% match (student papers from 29-Jul-2018)
Submitted to Kenyatta University on 2018-07-29

< 1% match (Internet from 22-Jul-2020)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/90549/Okombo_Influence%20of%20customer%20perceptions%20on%20the%20adoption?sequence=1

< 1% match (Internet from 22-Jul-2020)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/90585/Nyabochwa_Factors%20influencing%20the%20use%20of%20agricultural%20insura?sequence=1

< 1% match (Internet from 09-Sep-2020)
https://www.standardmedia.co.ke/the-standard/article/2000200973/greenhouse-vs-open-field-which-is-greener

< 1% match (Internet from 12-Nov-2020)
https://www.intelligenteconomist.com/malthusian-theory/

< 1% match (publications)
Woldesenbet, M. and T Tana. "Effect of Integrated Nutrient Management on Yield and Yield Components of Food Barley (Hordeum vulgare L.) in Kaffa Zone, Southwestern Ethiopia", Science Technology and Arts Research Journal, 2014.

< 1% match (Internet from 22-Jul-2020)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/56396/Keru_Factors%20influencing%20contraceptive%20preference%20and%20choice%2?isAllowed=y&sequence=3

< 1% match (publications)
Yi Hu, Binbin Li, Zhenghe Zhang, Jian Wang. "Farm size and agricultural technology progress: Evidence from China", Journal of Rural Studies, 2019

< 1% match (Internet from 26-May-2019)
https://pdfs.semanticscholar.org/7a7e/06bccd7207ca8f506bdc587aa1ae27db98a84.pdf

< 1% match (Internet from 22-Jul-2020)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/90507/Omolo%20Florence%20A_Factors%20influencing%20uptake%20of%20voluntary%county.pdf?sequence=3

< 1% match (Internet from 09-Oct-2020)
ttps://theartsjournal.org/index.php/site/article/download/1966/897

< 1% match (Internet from 14-Apr-2020)
https://pdfs.semanticscholar.org/165b/d4d585736700e093752d70187dfef3f0282a.pdf

< 1% match (Internet from 22-Jul-2020)
http://erepository.uonbi.ac.ke/bitstream/handle/11295/9282/Machoka_Factors%20that%20influence%20gender%20disparity%20on%20primary%?isAllowed=y&sequence=1