AGRICULTURAL INFRASTRUCTURE AND ITS IMPLICATIONS ON SUSTAINABILITY OF SMALLHOLDER MANGO FARMING IN ELGEYO MARAKWET COUNTY, KENYA

BY

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DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented in any other University. No part of this thesis may be reproduced without the prior permission of the author /or Moi University, Eldoret**.**

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DEDICATION

I dedicate this thesis to my beloved husband Naftali Kiplagat for being the encouragement throughout this noble course. To my sons Ellison Kibet, and Ethan Ngetich who encouraged me and have been the best cheerleaders. A special feeling of gratitude to my parents Mr. and Mrs. Henry Kirui, whose words of encouragement and push for tenacity ring in my ears. May God bless you most abundantly!

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ABSTRACT

Globally, agricultural infrastructure plays a vital role in economic growth. Developing agricultural infrastructure improves livelihoods and sustainable, environmentally friendly agriculture. Despite its importance for livelihood, growth, and development, smallholder farming competitiveness and agricultural infrastructure adoption in Africa remain limited. Inadequate infrastructure can be a significant constraint to growth and productivity. This study examined agricultural infrastructure and its implication on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya. The specific objectives were to: examine the agricultural infrastructure strategies adopted, evaluate the nature of stakeholder involvement in agricultural support, assess the effects of agricultural infrastructure on sustainable smallholding and establish the challenges on the use of agricultural infrastructure. The scope of this study was restricted to the mango growing areas of Elgeyo Marakwet County. The research focused on agricultural infrastructure and its impact on the ability to improve livelihoods. The study was anchored on Sustainable Livelihood theory by the Department for International Development (DFID). The study adopted mixed methods approach utilizing cross- sectional survey design. Simple random sampling was applied to select a sample size of 370 small holder mango farmers from a total population of 9200; purposely selected 10 key informants and carried out 3 FGDs. Data collection instruments included questionnaires, interview schedules, observation, document reviews and focus group discussions. Descriptive statistics were analyzed through frequencies, percentages and means. Inferential statistics employed, Chi-square test, and regression analysis .Qualitative data was analyzed thematically, where labels were assigned to various categories and themes**.** The findings indicate that the small holder farmers are using agricultural infrastructure which include use of dominant seeds apple (74.3%), spraying of mangoes (55.4%), training (80%), access of information from extension officers 53.4%, and the main source of financing was savings (68.9%.).The role of various stakeholders in agricultural support was low on provision of subsidized inputs for farmers, water and electricity, roads infrastructure, prices and marketing of the mangoes and streamlining of mango price (Mean=1.40,SD=0.79,Skewness= 2.62, Kurtosis=7.5). Further, Chi-Square values were statistically significant for the items tested $F(3,350) = 10.43$, $P < 0.05$) indicating that agricultural infrastructure which consist of physical infrastructure, input based infrastructure, resource based infrastructure and institutional based infrastructure significantly affected the output enhancing agricultural sustainability .Several challenges were associated with use of agricultural infrastructure include the lack of certified seeds, availability of quality planting seeds, high price and lack of timely availability of fertilizers. The Principal Component Analysis indicates that the two components accounted for about 57.98% of the variance. It was concluded that stakeholder's involvement in agricultural support is low; use of agricultural infrastructure is associated with several benefits and challenges. The study proposes creating a business-friendly environment for smallholder mango growers and making small-scale farming appealing to younger generations, as well as improving and harmonizing stakeholders' roles in inputs, infrastructure, price regulation, marketing, and community collaboration. Integrating proper policies and agricultural infrastructure practices will increase their utilization and sustainability.

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LIST OF ABBREVIATIONS

AFDB : Africa Development Bank

CBOs : Community Based Organizations

CIDP **:** County Integrated Development Plan

FBOs : Faith Based Organizations

GDP : Gross Domestic Product

ICLEI : International Council for Local Environmental Initiatives

IS : Informal Settlement

MDGs : Millennium Development Goals

NEMA : National Environmental Management Authority

NGO : Non- Governmental Organization.

PRSP : Poverty Reduction Strategy Paper

SEC : Settlement Executive Committee

UNDP : United Nations Development Programme

UNEP : United Nations Environment Programme

WCED : World Commission on Environment and Development

DEFINITION OF TERMS

Development - Overall advancement of communities' living standards towards meeting the basic needs

Household - Refers to the basic unit of a society where individuals both cooperate and compete for resources.

Sustainability - the practice of maintaining processes of productivity indefinitely, natural or manmade, by replacing the resources used with resources of equal or greater value without degrading or endangering natural biotic systems

Sustainable Development - development that meets the needs of the present without compromising the ability of future generations to meet their own needs

Small Holder: smallholder farmer are agriculturalists involved in farming small piece of land, cultivating food crops, sometimes with small varieties of cash crops and rely exclusively on household labour.

Small Holding: Farms supporting a single family with a mixture of cash

Crops and subsistence farming

Physical Capital: Basic infrastructure and producer goods needed to support livelihoods.

Social Capital: Informal networks, membership of formalized groups and relationships of trust that facilitate co-operation.

Human Capital: Encompasses the abilities, experience, work skills and the good health that, when combined, allow populations to engage with different livelihood strategies and reach their own objectives

Livelihood: A livelihood includes competences or resources which includes both physical and social assets and activities necessary for a way of existing

Natural Capital: The stocks of natural resources from which further resources and financial resources that people use to achieve their livelihood objective

Financial Capital: Financial resources that people use to achieve their livelihood

Objectives

Input based infrastructure: Seed, Fertilizer, Pesticides, Farm equipment and Machinery

Resource based infrastructure: Water/irrigation, Farm power/energy

Physical infrastructure: Road connectivity, Transport, storage, processing and Preservation

Institutional infrastructure: Agricultural research, extension & education Technology, Information & communication services, financial services And marketing

CHAPTER ONE

1.0 Overview

The chapter presents the significant components that lay the foundation to the study namely; background of the study, problem statement, objectives of the study, justification, significance, scope and limitation of the study.

1.1 Background of the Study

Globally, a majority of the population depends directly or indirectly on agriculture, the sector is expected to play a central role for livelihood, growth and development. It is therefore seen as the main source of livelihood. Smallholder agriculture has played, and continues to play, a key role in global economic development. It is estimated that more than 90% of the 570 million farms worldwide are managed by an individual or a family, producing more than 80% of the world's food, IFAD (2013). Further, according to the Food and Agriculture Organization of the United Nations (FAO) 80% of farmland in sub-Saharan Africa is managed by smallholders working on up to 10 hectares which makes smallholder production the backbone of agriculture in sub-Saharan Africa (FAO, 2017). Additionally, in Latin America, smallholder farmers occupy almost 35 per cent of total cultivated land (Altieri and Koohafkan, 2008). Generally, smallholder farming systems are very diverse, and contribute considerably to global agricultural output of a variety of crops and in many instances their contribution is growing (Koohafkan, 2011). However, a striking three quarters of the world's extreme poor 800 million people live in rural areas and most food insecure people on the planet and nearly half of the world's undernourished people are smallholder farmers [FOA, WFT and IFAD (2012)] who purely depends on agriculture (World Bank, 2008). It can therefore be argued that, food supply and the livelihood of billions of people depend largely on the productivity of these systems (FAO, 2012). On the other hand, scientists have warned that in order to

prevent a food crisis, pre-emptive measures should be taken to make these small-scale farms sustainable while avoiding intensive resource use (Sarantis M., 2016).

Smallholder farmers supply about 70 per cent of Africa's total food requirements and provide around 80 per cent of the food consumed in both Asia and sub-Saharan Africa. Furthermore, smallholders in several developing countries produce the bulk of these countries' main agricultural exports. For example, in Malawi mango production is dominated by thousands of smallholder producers cultivating less than 2 hectares per farm. Owing largely to its smallholders, Ghana produces an estimated 20 per cent of the world's cocoa, making the country the second largest producer in the world, with cocoa exports accounting for about 40 per cent of its foreign exchange earnings and for 8–12 per cent of its gross domestic product. However, despite their important contribution smallholders have suffered from benign neglect by policymakers, local as well as by the international community. As a result, smallholders in the developing world continue to account for a large proportion of the poor. Estimates show that 70 per cent of the developing world's 1.4 billion extremely poor people (FAO 2020).

There is a global consensus that one of the key sectors that smallholder farming is employed is the horticultural sector, especially mango production. Mangoes are produced in over 90 countries, with Asian countries accounting for approximately 77 percent of global production, followed by the Americas (13 percent) and Africa (10 per cent). According to FAOSTAT (2011), the top five mango-producing countries are India (40.1 percent), China (11.5 percent), Thailand (6.9 percent), Indonesia (5.6 percent) and Mexico (4.8 percent). On a global scale, Kenya contributes about 1.7 percent of worldwide production, and is ranked number 15 after Vietnam (1.8 percent). Kenya is ranked second to Nigeria in Africa, and is the leading mango producer in East

Africa, contributing about 43 percent of the region's total production volume (UNCTAD, 2011).

According to FAO (2020), Agricultural Infrastructure plays a vital role in mango farming at every single step like for the supply of input, sowing of crops and for the post-harvest management. Planned investment in agricultural infrastructure sector is important to enhance the productivity and to reduce the post-harvest losses which will also result in capacity building and higher income generation. In Kenya, post-harvest losses are relatively higher because of gap of basic agriculture infrastructures like storage houses, processing, absence of proper supply chain etc.

Agriculture is the key to Kenya's economy, contributing 26 per cent of the Gross Domestic Product (GDP) and another 27 per cent of GDP indirectly through linkages with other sectors. The sector employs more than 40 per cent of the total population and more than 70 per cent of Kenya's rural people. The sector also accounts for 65 percent of Kenya's total exports and provides more than 18 percent of formal employment derived from various sectors like horticulture. The horticulture (fruits, flowers and vegetables) sub sector in rural Kenya is among the most vibrant in the agriculture sector after tea and coffee contributing to the agriculture GDP at 33 % and has had an annual average growth of between 15 % and 20 % per year (Kenya Economic Survey, 2016). Sustainable Agriculture should be considered across the value chain from producer to the retailer. Sustainable Agriculture includes, at a minimum, the environmental and social impacts of production. Also to be considered is product integrity (e.g., quality, safety and traceability) and the potential positive economic impacts of Sustainable Agriculture on mango production and retail sales.

The productivity of smallholder agriculture and its contribution to the economy, food security and poverty reduction depend on the services provided by well-functioning ecosystems, including soil fertility, freshwater delivery, pollination and pest control. Smallholder farming practices, in turn, affect the condition of ecosystems. These impacts are not always negative, but poverty and immediate needs can drive smallholders to put pressure on ecosystems, for example through habitat modification, over extraction of water and nutrients, and use of pesticides. With the right conditions, smallholders can be at the forefront of a transformation in world agriculture. With their immense collective experience and intimate knowledge of local conditions, smallholders hold many of the practical solutions that can help place agriculture on a more sustainable and equitable footing. To do this, they need help to overcome market failures and other disincentives for sustainable land use, including insecure land tenure, high transaction costs and weak institutional support. A major challenge will be to address the discrepancies of scale between decisions made at the farm level and impacts at larger ecosystem scales. Sustainability, is defined as the practice of maintaining processes of productivity indefinitely, natural or man-made, by replacing the resources used with resources of equal or greater value without degrading or endangering natural biotic systems (Hendrick, 2014).Further, Sustainable Development has been defined in many ways, but the most frequently quoted definition is from *Our Common Future*, also known as the Brundtland Report (WCED, 1987), which defined "Sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It contains within it two key concepts:

- The concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and

- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

Sustainable development is a three-dimensional model, which comprises of economic, environmental and social or ecology, economy and equity (UN, 2014), some authors have added a fourth pillar of culture and institutions of governance (Hawkes, 2001; Screrri *et al.,* 2010). Local governments' initiatives are crucial in order to achieve sustainable development through agricultural infrastructure. Therefore, sustainable development and its issues should be majorly directed towards the rural environment and challenges caused by poor agriculture infrastructure that is mainly evident in smallholder farming.

One of the most important factors that hinder development in transitional societies is poor infrastructure which has contributed to the decrease in farm productivity in rural areas. With many governments seeking effective ways to lead their nations out of such challenges, agricultural infrastructures have been proposed as a means of dealing with such challenges and in attainment of Sustainable Development Goals (SDGs) (AFDB, 2013). The seventeen SDGs cover three salient aspects of global development, namely, poverty eradication, shared prosperity, and the protection of the planet, all premised on peace and partnerships. The goals include specific targets that are to be addressed by the year 2030 by governments, the private sector, and civil society (UN, 2015). Thacker *et a*l. (2018) show that infrastructure has a direct influence on more than 80 % of the 169 individual SDG targets. Sustainable infrastructure underpins the delivery of all the social SDGs. Perhaps, most pertinent is the role of infrastructure in alleviating poverty (SDG 1), which is crucial to global development, given that 3.5 billion people are still living below the poverty line (Atamanov *et al*., 2018). Improved access to basic

services is one of the fundamental objectives of infrastructure development, and sustainable agriculture infrastructure, since it integrates electricity, transport, clean water and sanitation services and is closely associated with poverty alleviation, through providing not only increased access but also via the expansion of economic opportunities and streamlined information channels (Bhattacharya *et al*., 2016).

According to Goyol & Pathirage (2017), agricultural infrastructures are categorized into:

[i] Capital intensive, like irrigation, roads, bridges.

[ii] Capital extensive, like extension services.

[iii] Institutional infrastructure, like formal and informal institutions.

Infrastructure, such as irrigation, watershed development, rural electrification, roads, and markets, in close coordination with institutional infrastructure, such as credit institutions, agricultural research and extension, rural literacy determines the nature and the magnitude of agricultural output in developing countries.

Further, agricultural infrastructure can be grouped under the following broad based categories, (Du, Pinga, Klein & Danton, 2015 and Patel (2014).

- Input based infrastructure which included Seed, Fertilizer, Pesticides, Farm equipment and Machinery.
- Resource based infrastructure which includes Water/irrigation, Farm power/energy
- Physical infrastructure will include Road connectivity, Transport, storage, processing, preservation, etc.

- Institutional infrastructure comprises of Agricultural research, extension & education technology, information & communication services, financial services, marketing, etc.

Other researchers such as Donaldson, (2018), Chengappa, (2018), Baba, Mir, Khan, Bazaz & Manzoor, (2015), have identified 11 components of infrastructure, such as; irrigation and public access to water; means of transportation; storage services; commercial infrastructure; processing infrastructure; public services; agricultural research and extension services; communication and information services; land conservation services; credit and financial institutions and ; health and education services. Though there exist various categories of agricultural infrastructure, the study will be based on the four categories by Du, Pinga, Klein & Danton, (2015) which include Input based, Resource based infrastructure, Physical infrastructure and Institutional infrastructure.

Isakson (2014), argues that agricultural infrastructure has the potential to transform the existing traditional agriculture or smallholder farming into a most modern, commercial and dynamic farming system in any country depending on agriculture. However, poor infrastructure in Africa is often listed as one of the major challenges to agricultural growth and development for the continent. Less than 50% of the rural populations live close to adequate roads, which pose difficulty for farmers transporting inputs and produce. This coupled with poor storage facilities in the continent, leads to post-harvest losses with the United States Department of State predicting that nearly one third of global agricultural production either arrives in poor condition or never makes it to the consumer at all. Evidently, the issue of agricultural infrastructure is one that urgently

needs to be addressed if in order to solve some of the world's biggest challenges and cut the unnecessary waste at farm level.

Agriculture remains the backbone of the Kenyan economy. It is the single most important sector in the economy, contributing approximately 25% of the GDP, and employing 75% of the national labour force (Republic of Kenya 2019). Over 80% of the Kenyan population derives their livelihoods, directly or indirectly from small holder farming. Given its importance, the performance of the sector is therefore reflected in the performance of the whole economy. Agricultural agriculture is important for poverty reduction since most of the vulnerable groups like pastoralists, the landless, and subsistence farmers, depend on agriculture as their main source of livelihoods. In case of poor and inadequate agricultural infrastructure, performance of small holder mango farmers is affected right from the production to marketing domestically and internationally. For exports this means lack of sustainable supply of mangoes due to uncontrolled production, with gluts alternating with shortages. This study looks at these hidden aspect that are always ignored yet they play an instrumental role in sustainability of small holder mango farming.. This is even worse in ASAL dominated areas where there is problem with mobility, cattle rustling and harsh climatic condition and inadequate agricultural infrastructure.

It is against this background that the study examined agricultural infrastructure and its implications on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya.

1.3 Statement of the Problem

Globally, fruit crops play an important role in the national food security and they are generally delicious and nutritious. Fruits are a source of raw materials, foreign currency and employment opportunities. Agricultural infrastructure has significant impacts on the production and productivity of small scale agriculture with potential to reduce poverty and transform the existing traditional smallholder farming into modern, commercial, dynamic farming systems with enhanced farm productivity. Agricultural infrastructures are a means of dealing with the challenges in agriculture production and in attainment of Sustainable Development Goals (SDGs). From academic perspective, there is a consensus that agricultural infrastructure is a reality and there is need to focus on its implication to small holder farming. The proponents of sustainable livelihood approach including UNDP, FAO , UNACTAD and IFAD advocate for the focus on agricultural infrastructure for the sustainability of small holder farming which has been the major challenge to small holder mango farming in Elgeyo Marakwet County. In Kenya, ninety five percent (90%) of mango produced is made up of indigenous varieties which have high fiber content and are of little market value. Mango exports from Kenya are declining despite the expansion in demand for fresh fruits in Europe and the near East. This study stems from a practical observation that although Elgeyo Marakwet County has favorable climate condition for mango production, it is constrained by inadequate agricultural infrastructure which includes; low adoption of improved mango technologies, inadequate processing facilities, poorly developed transport infrastructure, unreliable supplies, poor agronomic practices, and inadequate postharvest handling techniques. These problems have resulted in smallholder mango farmers relying on local mangoes which are very small in size, highly perishable and have high fiber content. This study therefore looks at these hidden aspects that are always ignored yet

they play an instrumental role in sustainability of small holder mango farming; which is even worse in ASAL dominated areas where there is problem with mobility, cattle rustling and harsh climatic condition.

It's against this background that this study sought to examine Agricultural infrastructure and its implication on sustainability of small holder mango farming in Elgeyo Marakwet Kenya

1.4 Purpose of the Study

1.4.1 General Objective

The general objective of this study was to examine agricultural infrastructure and its implications on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya.

1.4.2 Specific objectives

The study was guided by the following specific objectives to:

i. Examine the agricultural infrastructure strategies adopted to enhance sustainability of smallholding mango farming.

ii. Evaluate the nature of stakeholder involvement in agricultural infrastructure support for small holder mango farming.

iii. Assess the effects of agricultural infrastructure on the sustainability of smallholding mango farming.

iv. Establish the challenges on the use of agricultural infrastructure on sustainable smallholder mango farming.

1.5 Research Questions

i. What are the agricultural strategies adopted to enhance sustainability of smallholding mango farming?

ii. What is the nature of stakeholders' involvement in agricultural support for small holder mango farming?

iii. What is the effect of agricultural infrastructure on the sustainability of smallholder mango farming?

iv. What are the challenges on the use of agricultural infrastructure on sustainability of smallholder mango farming?

1.6 Scope of the Study.

This study was done in Elgeyo Marakwet County involving three wards namely: Endo, Arrror and Soy North wards the mango growing areas in Elgeyo Marakwet County. The focus of the study was on small holder mango farmers. This study was confined to 370 small holder mango farmers and 10 key informants. The focus of the study is on examining agricultural infrastructure and the implication it has on the potential to transform livelihoods. Further, the study was based on the philosophical and methodological foundations of pragmatism. Mixed methods approach was used where cross sectional survey design made foundation of this research. The findings will be applicable three wards in Elgeyo Marakwet County, Kenya.

1.7 Limitation of the study

The researcher faced some logistic problems especially reaching out to the area of study because of mobility and topographical challenges. Some of the respondents were not willing to fill in the questionnaire or to provide information for fear of being victimized. However, there was persuasion and assurance that the information given will only be used for the purpose of the study, and that the information given would be treated with a lot of confidentiality. Another possible restraining factor was the fact that the

respondents were spread over a bigger geographical area, but this was countered by applying random sampling techniques to ensure unbiased selection.

1.8 Justification of the Study

Currently, there is growing emphasis on agricultural policies and practices which provides a response to various challenges including food insecurity, climate change, poverty and economic crises that the world has been experiencing with an alternative paradigm that leads to sustainability. One of such practices is the adoption of agricultural infrastructure. Since smallholding agriculture is the backbone of the economy, its contribution is crucial to food security, source of income and livelihoods of many households like arid and semi-arid areas in. in Elgeyo Marakwet County. Agricultural agriculture is important for poverty reduction since most of the vulnerable groups in Elgeyo Marakwet, like pastoralists, the landless, and subsistence farmers, depend on small holder agriculture as their main source of livelihoods. In case of poor and inadequate agricultural infrastructure, performance of small holder mango farmers is affected right from the production to marketing domestically and internationally. Addressing the challenges of small mango farmers through adoption of agricultural infrastructure will contribute towards improving the livelihoods of many households. The failure to address issues of smallholder farming would mean continued low production and increased post harvesting losses. Practically, agricultural infrastructure is a reality that can't be ignored in Kenya and specifically Elgeyo Marakwet County. The study identified the agricultural infrastructure already adopted and proposed appropriate recommendations for adopting more appropriate agricultural infrastructure practices. The study will be important in providing recommendations intended to fill the gaps and identifying loop holes that might have been overlooked by various stakeholders concerned with agricultural infrastructure for sustainable mango farming.

1.9 Significance of the Study

This study is significant in many ways. It will be useful to the stakeholders, county government, policy makers and development partners interested in getting a better understanding of the role played by agriculture infrastructure. The study will give some guideline information to policy makers, planners, environmental advocates, Non-Governmental Organizations (NGOs) and the researchers about Agricultural infrastructure and its implications in small holder mango farming and this will point to areas for further study. To academicians and researchers, the study may be a source of reference material for future researchers on other related topics; it may also help other academicians who will undertake the same topic in their studies. It is anticipated that the results have contributed to the existing knowledge on agricultural infrastructure and the implication to small holder mango farmers.

1.10 Chapter Summary

Globally, food supply and the livelihood of billions of people depend largely on the productivity of smallholder farming. However, most food insecure people on the planet and nearly half of the world's undernourished people are smallholder farmers who purely depend on agriculture. Elgeyo Marakwet County, is experiencing economic transformation as residents increasingly take up crop farming, particularly horticulture, like mango farming. However, the potential for horticultural production in the county has not been fully utilized to be of help to the communities. This leads to massive crop failures and therefore lack of food security. Therefore, in order to prevent a food crisis, pre-emptive measures should be taken to make these small-scale farms sustainable while avoiding intensive resource use. One of such measures is adoption of agricultural infrastructure which is considered a means of dealing with such challenges and in attainment of Sustainable Development Goals (SDGs).

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview

This chapter highlights the relevant literature review of the works by other scholars on agricultural infrastructure, small holder farmers and sustainability from both global and local perspectives. The various sections of the literature review were informed by the specific objectives of the study. The chapter also provided the conceptual framework and theoretical framework that guided the study.

2.1 Agricultural Infrastructure Concept

Sustainable Agricultural infrastructures are the most promising means of improving the productivity and resilience of agricultural production in smallholder farming systems while protecting natural resources. According to Goyol & Pathirage (2017), agricultural facilities are classed as I capital intensive, such as irrigation, roads, and bridges; and [ii] capital light, such as dams. [ii] substantial capital, such as extension services, and [iii] institutional infrastructure, such as official and informal institutions. Infrastructure, including irrigation, watershed development, rural electrification, roads, and markets, in close coordination with institutional infrastructure, such as credit institutions, agricultural research and extension, and rural literacy, determine the nature and magnitude of agricultural output in developing nations.

According to IFPRI (2019), women and girls make up nearly half of the agricultural workforce in developing nations, as more than 60 percent of all working women in sub-Saharan Africa are employed in agriculture. Access to critical agricultural inputs such as land, labor, knowledge, fertilizer, and better seeds and seedlings is unequal for women (FAO, 2011; Farnworth et al., 2016). According to Peterman et al. (2014) and Perez et al. (2015), women have less authority in decision-making and face additional social, cultural, and institutional barriers to acquiring and implementing agricultural

technologies. In addition, the diminished involvement of women is the result of gender disparities in agriculture and the adoption of new technologies, which are frequently linked to women's lack of access to land, education, extension services, training programs, and financial services (Team and Doss, 2011). A global gender gap exists in terms of women's agricultural risks, access to resources, and productivity (FAO, 2011; Perez et al., 2015). On the other hand, Duncan & Brants (2004) assert that men dominate plantation crop production in Ghana. A plantation crop such as mango necessitates a vast area of farmland, expensive initial money, and labor, all of which Ghanaian women often lack. However, there is a significant presence of women in the local distribution and marketing of mango products. In addition, MoFA (2011) reported that mango cultivation in Ghana is often regarded as a male activity, despite the fact that women play significant roles in post-harvest techniques and other farm management tasks such as weed control.

According to the Rockefeller Foundation (2018), very few women are recognized to be the ultimate owners of mango trees or the land on which mangoes are grown, and husbands have almost exclusive contact with mango dealers and entire control over the distribution of mango revenue.

According to Genius et al. (2014), younger farmers are more likely to embrace soil and water conservation methods in recent years, making them more likely to be early adopters of sustainability than older farmers, who are late adopters. Grammatikopoulou et al. (2015) demonstrate that early adoption of organic farming practices and regular contact with young and highly educated farmers improves the likelihood that organic farmers in Germany will implement additional agri-environmental measures (AEM). Ahmed et al. (2017) also discovered that people between the ages of 25 and 50 are

interested in mango production. This is because they have seen and realized the advantages of mango growing in comparison to other income-generating pursuits

2.2 Small Holder Farming Concept

Globally, there are approximately 2.5 billion people involved in full or part-time smallholder agriculture, managing an estimated 500 million small farms and providing over 80 per cent of the food consumed and ultimately contributing significantly to food security and poverty alleviation target of Sustainable Development Goals (SDGs) at all levels by 2030 (Jha, Kickbusch, Taylor and Abbasi, 2016). In sub-Saharan Africa and Asia small-scale agriculture produces up to 80 percent of the food consumed, well as the provision of over 70% of the workforce (Mkonda, 2017). Additionally, smallholder agriculture is also an important source of income and livelihoods of many poor households, working on land plots smaller than 2 hectares (Lowder and Singh 2014).This explains why in the last two decades a number of international development agencies have shown an increasing interest in agricultural development as a means of achieving widespread poverty alleviation and achievement of sustainable development (World Bank 2008, World Development Fund 2011, and IFAD 2011).

A smallholding or smallholder is a small farm operating under a small-scale agriculture model. Definitions vary widely for what constitutes a smallholder or small-scale farm, including factors such as size, food production technique or technology, involvement of family in labor and economic impact *(*www.sciencedirect.com)

According to Lowder and Singh (2014), smallholder farms are defined as being two hectares or less. The average size of a smallholder farm in Bangladesh and Vietnam is 0.24 and 0.32 hectares respectively. In Africa, smallholder farms can be relatively larger, but only marginally. Kenyan smallholders tend to farm 0.47 hectares and in

Ethiopia the average small farm size is 0.9 hectares. In Latin American countries, smallholder farms often tend to be over 2 hectares, as well as in Nicaragua where the average small farm size is 5 hectares. Conversely, Arias *et al.,* (2013) argues that smallholder agriculture is characterized by small production volumes of variable quality that reflect limited access to inputs and finance, low levels of investment and limited access to knowledge of improved agricultural technologies and practices. Additionally, Murphy (2010), notes that, smallholder farmers are characterized by marginalization, in terms of accessibility, resources, information, technology, capital and assets.

Smallholdings are usually farms supporting may be valued for the rural lifestyle. As the sustainable food and local a single family with a mixture of cash crops and subsistence farming. As a country becomes more affluent, smallholdings may not be self-sufficient, but may be values for the rural lifestyle. As the sustainable food and local food movement grow in affluent countries, some of these smallholdings are gaining increased economic viability. There are an estimated 500 million smallholder farms in developing countries of the world alone, supporting almost two billion people (Sarantis M., 2016).

Arias *et al.* (2013), notes that smallholders farming are therefore central to an inclusive development process and their contribution is crucial to food security. He argues that, although many are poor and food insecure and have limited access to markets and services, they farm their land and produce food for a substantial proportion of the world's population. Besides farming, they have multiple economic activities, often in the informal economy, to contribute towards their small incomes. Scientists have warned that in order to prevent a food crisis, pre-emptive measures should be taken to

make these small-scale farms sustainable while avoiding intensive resource use (Sarantis M., 2016).

The current debate on predominance of smallholder farming in Sub-Saharan Africa and Asia, according to FAO, (2010), cited in HLPE, (2013) and Thapa and Gaiha, (2011), is whether the development of this sub sector could act as the driver of development and poverty reduction. On the other hand, Jayne *et al.*, (2014) notes that there is a decreasing trend on average farm sizes in Sub-Saharan Africa as rural populations continue to increase and in Asia it is indicated that the smallholder model continues to predominate seemingly undermining any expectation that smallholder models of agriculture are likely to decline in significance through the development process. This implies that the smallholder model may well remain a significant feature of African agriculture in the coming years and deeper understanding of its potential role in achieving sustainable development is required.

Fresh tropical fruits are on winning ground in world markets and Lumpkin *et al.*, (2005) also pointed out worldwide production of fruit and vegetable crops have grown faster than that of cereal crops. Moreover, figuratively, pineapple accounts for 44 percent of the total traded volume, followed by mangoes (27 percent), avocados (12 percent) and papayas (7 percent). The main reason for increase in demand of tropical fruits is the growing familiarity of consumers with tropical fruits; their taste, nutritional value and cooking qualities (Yeshitla, 2004).

In Kenya's economy, agriculture is a key factor contributing to 26 percent of the Gross Domestic Product (GDP) and another 27 percent of GDP indirectly through linkages with other sectors. The sector employs more than 40 per cent of the total population and more than 70 per cent of Kenya's rural people. The sector also accounts for 65 percent

of Kenya's total exports and provides more than 18 percent of formal employment derived from various sectors like horticulture (FAO, 2020). The horticulture (fruits, flowers and vegetables) sub sector in rural Kenya is among the most vibrant in the agriculture sector after tea and coffee contributing to the agriculture GDP at 33 percent and has had an annual average growth of between 15 and 20 percent per year (Kenya Economic Survey, 2016). A report of the Horticultural Crops Development Authority (HCDA) shows that major fruits produced in Kenya in terms of volumes are bananas, mangoes, and pineapples (HCDA, 2010). Mangoes, however, seem more versatile than all others for their ability to thrive in low rainfall (500 mm - 1000 mm) and a wide range of temperature (10-42 degrees Celsius) which makes it suitable even for the arid and semi-arid areas like Elgeyo Marakwet County. Majority of the mango production in these areas takes place through smallholders.

2.2.1 Small Holder Global Mango Production

Mango cultivation is primarily a smallholder activity worldwide. According to Tewodros Bezu, *et al.* (2014), Mango (*Mangifera indica*) is a fleshy stone fruit belonging to the species *Mangifera,* consisting of numerous tropical fruiting trees in the flowering plant family *Anacardiaceae*. The mango is native to South Asia from where it was distributed worldwide to become one of the most cultivated fruits in the tropics. Additionally, mangoes are produced in over 90 countries, with Asian countries accounting for approximately 77 percent of global production, followed by the Americas (13 percent) and Africa (10 per cent). The total production area of mangoes in the world is around 3.69 million hectares and the total amount of mango production in the world is around 35 million tons by the year.

According to FAOSTAT (2011), the top five mango-producing countries are India (40.1 percent), China (11.5 percent), Thailand (6.9 percent), Indonesia (5.6 percent) and Mexico (4.8 percent). On a global scale, Kenya contributes about 1.7 percent of worldwide production, and is ranked number 15 after Vietnam (1.8 percent). Kenya is ranked second to Nigeria in Africa, and is the leading mango producer in East Africa, contributing about 43 percent of the region's total production volume (UNCTAD, 2011).

Mango is native to Southeast Asia from India to the Philippines and was introduced to East Africa in the 14th century. Currently, most mango exports, including small quantities of green immature mangoes (for pickles) are air-freighted. However, sea freight is becoming increasingly important. The main market for Kenyan exports is in the Middle East countries. Other markets include Holland, U.K, Belgium, South Africa, Germany and France. Other exporting countries are Brazil, Pakistan, India, South Africa and Mexico, which compete with Kenya. The world trade in mangoes has been increasing over the years, and both exports from Kenya and local consumption are currently expanding. The world market continues to become more price-competitive. Production in Kenya has also expanded with new planting of bright colored varieties. (UNCTAD, 2011).

2.2.2 Small Holder Mango Production in Kenya

Generally, it is agreed that the horticultural industry in Kenya has been very successful in the last three decades. Among the existing agricultural enterprises, horticulture offers the best alternative for increased food self-sufficiency, food security, improved nutrition, foreign exchange earnings and ensuring the generation of increased incomes

and employment thus improving on their livelihoods (Agricultural Sector Coordination Unit (ASCU) (2011), Ministry of Agriculture, (2010a).

However, the potential for horticultural production in the arid and semi-arid lands (ASALs) like Elgeiyo Marakwet of Kenya has not been fully utilized to be of help to the communities living in those regions (Ministry of Agriculture, 2010b). This leads to massive crop failures and therefore lack of food security (International Center for Agricultural Research in the Dry Areas [ICARDA], 2013).

According to FSD (2015), there has been an increase in mango processing in Kenya over the years in response to demand. The growth in the processing subsector is due to two major factors: the increasing local demand for mango juice, and the projected medium-term increase in raw mango available to the processing industry at lower cost. The availability of competitive locally processed pulp will offer incentives to substitute imported concentrate with locally produced pulp or juices.

Currently, the semi-arid region is experiencing economic transformation as residents increasingly take up crop farming, particularly horticulture, like mango farming to be less risky compared to pastoralism that exposes them to recurrent attacks by armed raiders (County Integrated Development Plan (CIDP) 2018-2022). The six different varieties of the fruit targeting different markets grown include Apple, Ngoe, Tommy, Fantaic, Keit and Keint that are popular in the vast Kerio Valley region as they have high demand. According to Kerio Valley Development Authority (KVDA), Elgeyo Marakwet County has more than 5,000 hectares of land under mango plantations with an estimated production of 75,000 tonnes per season, with approximately 9,200 farmers (CIDP (2018-2022). Majority of the region's mango production takes place through

small-holders and it is this cadre of producers that have been impacted worst by the profound changes that the sector has undergone in recent times either as a result of global (market) trends, disease outbreak, poor agricultural infrastructure or highly variable climate systems (Ghosh, 2013).

2.2.3 Sustainability Aspects of Small Holder Mango Farming

Sustainability can be defined as "the practice of maintaining processes of productivity indefinitely, natural or manmade, by replacing the resources used with resources of equal or greater value without degrading or endangering natural biotic systems" (Hendrick, 2014). Further, Sustainable development has been defined in many ways, but the most frequently quoted definition is from *Our Common Future*, also known as the Brundtland Report (WCED, 1987), which defined Sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It contains within it, two key concepts:

- "The concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

Sustainable development is a three-dimensional model, which is the economic, environmental and social, or ecology, economy and equity (UN, 2014). Some authors have added a fourth pillar of culture, institutions of governance (Hawkes, 2001; Screrri *et al*., 2010). The study adopted sustainable development as the ability of local governments and other development partners to adopt agricultural infrastructure strategy to enable small holder farmers to use available resources as a source of wealth creation and livelihoods while at the same time preserving the same resource so that it

can continue to serve the future generation. Local governments' initiatives are crucial in order to achieve sustainable development through agricultural infrastructure. Therefore, sustainable development and its issues should be majorly directed towards the rural environment and challenges caused by poor agriculture infrastructure that is mainly evident in smallholder farming (AFDB, 2013).

2.3 Empirical Studies

2.3.1 Agricultural infrastructure strategies and sustainability of smallholder mango farming.

The growth of rural areas is greatly aided by agricultural infrastructure, which is a classic example of a public good. According to Warner and Kahan (2018), access to reasonably priced physical infrastructure is a key factor in fostering competitiveness in agricultural value chains and ensuring the continued viability of the food supply. Infrastructure such as irrigation, energy, transportation, and pre- and post-harvest storage facilities are included, as are telecommunications and covered markets, agro-processing and packaging facilities, which add value to the domestic economy, and transportation and bulk storage facilities, which allow produce to move quickly and efficiently from the farm-gate to processing facilities and on to wholesalers. All of the essential support systems for agriculture, such as utilities, transportation networks, storage facilities, and financial institutions, are crucial to the smooth operation of the nation's food and fiber supply chains (Venkatachalam, 2003). There is empirical evidence that imply that a yearly reduction in poverty of 0.6% to 1% can be achieved by increasing infrastructure investment by a factor of three to four (Besely & Byrgess 2003).

Donaldson (2018), Chengappa (2018), Baba, Mir, Khan, Bazaz, and Manzoor (2015), among others, have identified 11 components of infrastructure, including I irrigation

and public access to water [ii] means of transportation [iii] storage services [iv] commercial infrastructure [v] processing infrastructure [vi] public services [vii] agricultural research and extension services. services related to the dissemination of news and other information Those in the fields of [ix] land conservation, [x] banking and finance, and [xi] health care and instruction. The analysis relied on the four kinds of agricultural infrastructure proposed by Du Pinga, Klein, and Danton (2015) and Patel (2014): input-based infrastructure; resource-based infrastructure; physical infrastructure; and institutional infrastructure.

As a classic example of a public good, agricultural infrastructure is crucial to the growth of rural areas. Warner and Kahan (2008) argue that access to affordable physical infrastructure is a key factor in fostering competitive agricultural value chains and ensuring the continued viability of the food supply. This includes things like irrigation, energy, transportation, and pre- and post-harvest storage that help with production on the farm; telecommunications and covered markets that keep transactions safe and secure; agro-processing and packaging facilities that add value to the domestic economy; and transportation and bulk storage that get crops from the farm gate to the processing facilities and on to the wholesalers as quickly and efficiently as possible. So, everything from transportation networks to storage facilities is considered part of the agricultural infrastructure necessary for the smooth operation of the nation's food and fiber industries (Venkatachalam, 2003). To reduce poverty by 0.6% to 1.0% annually, empirical research indicates increasing infrastructure investment by a factor of three to four (Besely & Byrgess 2003).

Adepoju and Salman (2013) state that irrigation and public access to water, transportation, storage services, commercial infrastructure, processing infrastructure,

public services, agricultural research and extension services, communication and information services, land conservation services, credit and financial institutions, health and education services, and so on are all part of the agricultural infrastructure.

According to Du Pinga, Klein & Danton (2015) and Patel (2014) agricultural infrastructure can be grouped under the following broad based categories; Input based infrastructure which includes Seed, Fertilizer, Pesticides, Farm equipment and machinery etc.; Resource based infrastructure includes Water/irrigation, Farm power/energy ; Physical infrastructure comprises of Road connectivity, Transport, storage, processing, preservation, etc.; Institutional infrastructure involves Agricultural research, extension & education technology, information & communication services, financial services, marketing, etc.

2.3.1.1. Input based infrastructure

FAO (2010) and Miller et al. (2010) emphasize that seed is now developed primarily to address the needs of larger farmers, while smallholders are neglected; hence, the supply of improved seed in Africa is very low. They imply a significant chance to advance smallholder agriculture through the creation and dissemination of seeds of more resilient crops that will flourish in smallholder cultivation settings. To reduce this yield gap, Meehan et al. (2011) argue that more research and development into inputs like (artificial) fertilizers and insecticides is required.

Hesselberg (2010) contends that after the adoption of Structural Adjustment Programs, farmers who had become reliant on inexpensive inputs such as chemical fertilizer were suddenly confronted with dropping commodity prices and rising input costs. For small-scale farmers in poor nations, the lasting effects of this price slump have been devastating. Berhane et al. (2018) discovered that having access to an extension system

considerably enhanced the use of modern inputs like chemical fertilizers and better seeds. However, they also pointed out that the extension system has mostly concentrated on easing distribution of contemporary inputs and has yet to become knowledge-based, which may explain why the impact on productivity has not been as significant as projected.

Sheahan and Barrett (2017) state that input subsidies enlighten farmers who have never utilized enhanced inputs on food crops on the advantages of certified seed and fertilizer and encourage the development of commercial market channels but are unable to afford or gain access to inputs on their own.

According to Shaaban & Shaaban (2012), a suitable fertilization program is required in mango farming to prevent a loss in production and fruit quality, as well as the imbalance in nutritional status that causes the biannual bearing phenomenon in mango plants. Tewodros et al. (2018) observed that while some growers (36.3percent to be exact) did use organic fertilizers (compost and manure), the main reasons for avoiding inorganic fertilizers were a lack of understanding, expense, and accessibility. Similar results were found by Hussen and Yimer (2013): 90% of northern Ethiopia's mango growers did not use fertilizer.

Mirjat et al. (2011) discovered that for mango orchards to grow and develop healthily, sufficient watering is required at crucial stages like flowering, fruiting, and maturity. The amount and frequency of irrigation, however, is influenced by a number of parameters, including the age of the tree, the growth stage, the climate (humidity, rainfall, and temperature), and soil conditions (Mirjat et al., (2011); Sarker and Rahim, (2013).

2.3.1.2. Resource based infrastructure

AFDB (2011) contends that even when farmers attain increased agricultural yields through input subsidies, good rainfall patterns, or irrigation infrastructure, their harvests are at danger due to insufficient storage facilities. Furthermore, they believe that food availability in underdeveloped nations decreases merely a few months after harvest due to vendors' inability to keep perishable items.

Mrema (2017) indicated that a rise in the price of pesticides and herbicides diminishes the output of small-scale farmers. It was discovered that the cost of manure has a negative and considerable effect on mango production. A one-unit increase in the cost of manure reduces mango production by a ratio of 0.0934. According to information gathered from farmers who did not raise livestock, the price of manure was too high for them to afford, resulting in a drop in soil fertility and production. These results are consistent with Tun et al (2020) who concluded that a rise in the cost of manure decreases agricultural productivity in the arid zone of Myanmar.

Alam et al. (2017) determined that the amount of land devoted to mango cultivation (farm size) has a substantial impact on the quantity of mango produced by small-scale farmers. In contrast, prior research has suggested that smaller farms are more productive than their bigger counterparts, resulting in an inverse relationship between farm size and output (Desiere, 2016; Daudi and Omotayo, 2018).

Emongor (2015) claims that storage of matured mango fruit in open air and above or below the optimum temperature requirement of the crop shortens postharvest life and decreases fruit quality due to quick softening of the fruit, which makes the fruit susceptible to handling damages and postharvest pathogens. Thus, it is imperative that

growers find better mango storage methods that can preserve the fruit's freshness and lengthen its shelf life.

Sivakumar et al., (2011) acknowledges that Mangoes' postharvest losses, organoleptic, nutritional, and functional quality features, and marketing costs are all negatively impacted by poor packaging, shipping, and field handling techniques.

Griesbach (2003), state that the quantity of precipitation in a given region is not as crucial to mango growth as its intensity and distribution. Mangoes only need 500–1000 mm of rain at the correct time of year to grow. Mango, on the other hand, struggles in environments with heavy precipitation or excessive humidity during the blossoming stage.

2.3.1.3. Physical Infrastructure

Serem, (2010), pointed that poor transport infrastructure, especially the rural and trunk roads constitute significant challenge to Agriculture in Africa. Not only are there few roads, but transport costs in Africa are among the highest in the World, reaching as much as 77% of the value of exports (Serem, 2010).

Mangoes grown in the tropics and subtropics are already subjected to additional stress from the weather, and their deterioration is hastened by the high humidity and heat. Brecht et al. (2010) reported that mangoes are prone to numerous physical, physiological, and pathological abnormalities, including anthracnose, jelly seed, and sunburns. Mango pricing and competitiveness are lowered as a result of a number of issues that arise after harvest.

Abubakar and Sule (2019) conclude that household size is one of the factors determining the level of production and productivity of small-scale farmers. This

contradicts Muyanga and Jayne's (2019) findings that increasing household size leads to competition for resources and sub-division of land, which in turn affects crop yield.

Value-adding agro-processing facilities can be found in the areas of meat and fish freezing and processing, milk cooling and dairy processing, grain milling and refining plants, fruit processing, and various types of bottling and packing (Warner, Kahan and Lehel, 2009). In Africa, post-harvest losses for fruits, potatoes, and vegetables are often around 50%, which is double the rate seen in industrialized countries. If farmers don't have access to refrigerated warehouses and other cold-chain infrastructure, they have to sell their harvests in bulk soon after it's picked, which drives down prices. According to Larsen, Kim, and Theus (2009), agro-processing facilities assist farmers gain access to new urban and worldwide markets while also reducing post-harvest losses and economic losses.

Fruit boxes and cartons should have only one layer of mangoes, as recommended by the Transport Information Service (TIS) of the German Insurance Association (GDV e.V.). Packaging the fruit in paper or padding it with wood wool, bast fiber, straw, or hay is common practice due to the extreme pressure sensitivity of the produce. Gathambiri et al. (2009) conducted research in the country's eastern area and found that a shortage of suitable packing materials is one of the difficulties farmers confront.

2.3.1.4. Institutional infrastructure

When people are involved in the decision-making process, local capacity is increased, and a culture of learning is fostered, it is a sign of strong institutions. While strong institutions lead to sufficient funding, accountability mechanisms, technical proficiency, investment, and infrastructure, weak institutions cause the opposite (Pinto et al., 2014).

In underdeveloped nations, a 'farmer to farmer approach' is frequently used as an extension strategy. Model farmers are selected by a development organization based on criteria developed in consultation with the farmers. In most cases, factors including education, leadership, business performance, and personality attributes are considered (Muok et al., 2001). The model farmers receive instruction and resources including livestock and farming equipment. Farmers are urged to take cues from the "model farmer," and the "model farmer" is obligated to inspire and instruct their colleagues by freely imparting knowledge (Muok et al., 2001).

Many people believe that farmers and agribusinesses can't function without the structure provided by government agencies and other such organizations. Government measures, such as industrial policy or levels of investment in infrastructure, will have an effect on agriculture, and mediation is an efficient way to resolve conflicts over land rights (FAO, 2011).

Ahlerup, Olsson, and Yanagizawa (2009) opine that informal institutions are frequently based on local culture and practices. Poorer smallholder farmers can more easily have access to them, and they are more likely to be able to meet their demands. Local informal institutions are not static but rather part of a process of negotiation. As a result, efforts to fortify social institutions can be a key factor in alleviating poverty (Nyangena & Sterner, 2008). Local institution strengthening and buy-in have been widely credited for ensuring the long-term success of agricultural development projects (FAO, 2011).

According to OECD, (2007), expanding rural finance markets is a top goal under an improved incentive structure that enables the agriculture sector to serve as a significant driver of growth that benefits the poor. However, most donors have supplied very little funding for rural finance in the previous two decades, and many partner nations' major

involvement in this area of activity has terminated as part of structural adjustment initiatives. As a result, there is now a severe shortage of short-term loans for farmers. Small producers and firms often rely on self-financing or household financing, the sale of livestock and other assets, loans from local money lenders, or remittances from family and friends to finance the purchase of productivity-enhancing technologies or access to new markets because private banks may still service the needs of large commercial enterprises. It is not possible nor desirable to revert to the earlier government-subsidized credit schemes, which were characterized by artificially low interest rates and high default rates. Government engagement in the past has been costly and inefficient when it came to the management and implementation of financial systems in rural areas. Both a lack of responsible repayment practices and the financial instability of lending organizations afflicted the schemes (OECD, 2007).

OECD, (2007) further note that poor rural households, especially those headed by women, and businesses in most of the developing world today are unable to get financing on competitive terms, which prevents them from investing in new economic prospects and raising their earnings. Moreover, rural people and businesses may withdraw from profitable initiatives while having sufficient liquidity if they lack proper access to risk-reduction mechanisms (such as weather-based crop or insurance for commodity market pricing). Poor rural households' already limited access to capital is further drained when they are denied access to effective means of saving. There are many obstacles to thriving financial markets in rural locations (OECD, 2007)

Financial services are under-provided because of the high transaction costs associated with dispersed people and insufficient physical infrastructure, as well as the unique requirements and increased risk factors of the agricultural sector (USAID, 2003). It is

essential that plans be made to foster growth in the rural financial market so that all rural residents can gain fair access to financial services for their personal and professional endeavors.

According to the Financial Sector Deepening (FSD) (2015), the majority of mango farmers in Kenya's lower eastern area finance their mango operations through their own savings and informal service providers. This, they say, is evidence of the difficulties in securing formal finance, with the major cause being farmers' "inability" (lack of funds) to service structured monthly installments throughout the input application season. According to the report, only very large-scale farmers who are able to meet the lending conditions (primarily the collateral and regular monthly installment requirements) of these organizations are able to obtain official funding from banks. Financial organizations rarely extend loans to farmers.

Kameri (2012) suggest that training and research are crucial to running a successful business, and it was suggested that marketing research be stepped up and made available to farmers. Farmers' long-term prosperity and health depends on their level of marketing education and their capacity to participate fairly in the marketplace (Serem, 2010).

2.3.2 Nature of stakeholder involvement in agricultural infrastructure and small holder mango farming.

The role of stakeholders on the implementation of mango farming is important towards scaling rural incomes and reducing poverty for small-holder farmers while improving the market access for small-holder farmers.

Msabeni,et al. (2010) conducted an investigation of the organizational links along the mango value chain in Mbeere District Eastern Province, Kenya, and found that while there were many stakeholders/actors along the chain, including farmers, agents/buyers, service providers, input suppliers, processors, wholesalers, exporters, and consumers (end users), their linkages were poor because they functioned in isolation and lacked information at various levels. As an illustration, the producers lacked knowledge about the marketplaces, producer prices, and suitable agrochemicals.

Isakson (2014) indicate that the challenges facing smallholder farmers are well known. Rural families living off the sale of cash crops have very little material savings and the little they have can be wiped out in a single bad harvest. Smallholder mango farmers living in remote areas face difficulties accessing both input and output markets. The generation sold techniques, inputs and equipment employed by smallholder farmers are relatively inefficient, and often produce low yields. The vast majority have no titles to the land on which they work, basic market information or any form of training. Therefore the stakeholder's involvement is key in supporting small holder farmers to overcome such challenges (Isakson (2014).

2.3.2.1 Service Providers

Agricultural extension bridges the gap between agricultural technology research and development and actual production; it is a crucial link in transforming scientific research outcomes into agricultural productivity (Cook, et al., 2021). Li et al., (2008) notes that agricultural extension service plays a crucial role in promoting agricultural technology by emphasizing government participation, control, and institutional ties. But for a long time, it has been difficult for extension services to adapt to the diverse technical needs of farmers, resulting in a lack of agricultural technology and inefficient extension services. In light of this, the subject of whether government extension

services are still helpful in boosting farmers' adoption of environmentally friendly technologies in the current market climate merits investigation. In addition, farmers' decisions are influenced by their cognitive ability and their surrounding environment. Farmers' decision to use organic fertilizer may be influenced by their awareness of environmental benefits.

Bernstein (2014) notes that agricultural extension services can raise farmers' intelligence, hence encouraging their usage of organic fertilizer. In addition, due to the fact that farmers are both "economical people" and "social people," their behavior tends to be more logical due to the combined effect of the two jobs. Farmers' conduct is easily impacted by the external environment, which includes interpersonal connections, social networks, and cultural traditions (Castillo et al., 2021).

However, Ntakayo et al. (2016) found that the number of extension visits had no effect on the apple productivity of small-scale farmers. Farmers did not utilize extension agent-delivered practices such as the utilization of better production technologies such as pruning and spraying, among others, in an acceptable manner.

2.3.2.2 Credit facility Providers

Farmers, who make up the bulk of the population in most developing nations, can enhance their output and income by adopting new technology and taking advantage of economic possibilities if they have access to cheap agricultural finance. On average in developing nations, only 5% of borrowers have received 80% of the credit, while only 5% of farmers in Africa and 15% in Asia and Latin America have had access to formal credit (Bali, 2001).

Farmers can increase their output and efficiency by using modern agricultural technologies. However, small farmers typically lack the financial resources necessary to self-finance the purchase and implementation of cutting-edge agricultural technology. Financial constraints are commonly recognized as a significant barrier to farmers' investments, which are essential for raising agricultural output (Townsend, 2008).

Ramakrishnan and Kumar (2010) indicates that the Indian Government has initiated several policy measures to improve the accessibility of farmers to the institutional sources of credit. The emphasis of these policies has been on progressive institutionalization for providing timely and adequate credit support to all farmers with particular focus on small and marginal farmers and weaker sections of society to enable them to adopt modern technology and improved agricultural practices for increasing agricultural production and productivity.

Kebede (1995) found that the use of credit increased the productivity of conventional farming by allowing farmers to invest in machinery, fertilizer, and other inputs, as well as to install sophisticated irrigation systems. Market stability can also be achieved through the usage of credit. Establishing storage facilities and providing transport system acquired through credit can increase the bargaining power of rural farmers.

2.3.2.3 Market

Kirsten et al. (2008), insufficient communication and transport infrastructure prevents African agricultural markets from serving the best interests of society. Highly specific and limited markets increase the likelihood of market failure and market omission. Janvry et al. (1991) describe market failure as when the cost of dealing through market exchange creates disutility that is larger than the utility gain it generates, resulting in the non-use of the market for transactions. In such a case, the transaction will either be

facilitated by a substitute institution or will not take place at all. Over time, institutional frameworks are developed in response to market failures.

Fischer and Qaim (2012) discovered that marketing in a group offers a higher price than selling individually among banana farmers in Central Kenya. Wollni and Zeller (2006) discovered comparable results among coffee farmers in Costa Rica. Fischer and Qaim (2012) pointed out that the additional expenses of delivering product to collection sites for farmers selling through groups means that pricing differences across the channels cannot be used as proxy for profitability. Individual marketing of tiny quantities of produce reduces the smallholder farmers' negotiating power and leaves them vulnerable to price exploitation by traders because of the lack of collective action in markets (Kherallah and Minot, 2001).

Mwangangi et al. (2012) discovered that existing farmer groups work inefficiently and only convene when farmers need to sell their produce; hence, farmers lack faith in them. When the group of farmers is offered a higher price by the middlemen, they break the contract. The effectiveness of collective action by mango producers in gaining entry to formal channels should be assessed.

Jayne and Muyanga, (2006) avers that the major impediment to improved smallholder agricultural productivity in Africa has been limited access to indispensable inputs such as improved seed varieties and fertilizer. This problem is exacerbated by a lack of efficient output markets and gaps in policy which impair the effectiveness of market systems for vulnerable households that have lost productive assets such as manpower, agricultural equipment and cattle for ploughing due to a variety of reasons that include HIV and AIDS and poverty. The immediate need is basic support in the form of seed and fertilizer to produce food for the family. Once this need is met, additional support

in the form of assets, inputs, credit extension services and supportive policies is needed to help these households become more productive and enter commercial markets to generate income and improve their livelihoods.

Farmers sometimes use their own cars, rented trucks, or even public transportation vehicles called "matatus" to bring their harvest to nearby towns and cities. Most of these farmers sell at greater prices than those who sell at farm-gate despite transporting their mangoes in gunny bags, which reduces their quality and drives down their prices (Msabeni et al., 2010). Due to the lack of established marketing groups, the farmers who do focus on the direct market typically operate independently and do not use a middleman to get their goods to market.

2.3.2.4 Government

The economic pillar of Kenya's vision 2030 calls for an annual growth rate of 10 percent, and agriculture has been designated as a vital industry to accomplish this growth. Increasing smallholders' access to markets through more efficient supply chain management is one way to hasten expansion in the agricultural sector (GoK, 2007).

Kachule and Franzel, (2009) indicates that despite the favorable weather, cash crops including cotton, tobacco, sugar, tea, and groundnuts have more of a presence than the fruit business. Some of the issues that have contributed to the underdevelopment of the fruit business in Malawi include a lack of specialized employees and insufficient support from the government and the private sector.

Musyoka et. al., (2020) establish that the Ministry of Agriculture in Kenya should be in collaboration with the county government and other private partners to increase the number of cold-storage facilities among small scale mango farmers to promote the proportion of mangoes value added. They opined that since majority of mango farmers

are members of various forms of groups, value chain development agencies should target such groups for the provision of trainings on mango value addition practices.

Musyoka et. al., (2020) suggests that the government should take measures to enhance farmers' awareness of social trust, continuously improve the governance capacity of the village collectives, improve the role of village self-governance and social forces in agricultural infrastructure construction, and actively guide farmers and private enterprises to participate in agricultural infrastructure construction so that farmers can obtain more practical benefit.

Msabeni, et al. (2010) claim that the agents are heavily exploiting the gap in market information and prices, and that the use of subpar agrochemicals as a result has a negative impact on both the quality and quantity of crops. Additionally, the extension service providers are ill-equipped to counsel the producers due to their ignorance of shifting market demands. Bringing together many stakeholders through various forums would strengthen the connections and enhance information flow throughout the chain (HCDA, 2008).

With the foregoing literature, the study stepped out to bring out the nature of stakeholder involvement in agricultural infrastructure support for smallholder mango farming in Elgeyo Marakwet.

2.3.2.4 Non-Governmental Organizations

URT (2001) defines an NGO as "a voluntary group of individuals or organizations that is autonomous and not-for-profit sharing; organized locally at the grassroots level, nationally, or internationally for the purpose of enhancing the legitimate economic, social, and/or cultural development or lobbying or advocating on issues of public

interest or interest of a group of individuals or organizations." The phrase "nongovernmental organizations" (NGOs) can also apply to groups that are not affiliated with any government and are run only for charitable purposes (Wellard and Copestake, 1993).

NGOs are major players in the establishment of small-scale irrigation schemes and in their rehabilitation. They provide schemes that support farmers in different ways. Mutambora et al. (2014) indicate that Mtandawe and Dendere in Zimbabwe were established through NGS, World Vision and Red Barna respectively. They further reveal that after pegging by Agritex, the NGO would oversee the engagement of the community, consultants, contractors/ service providers and all the relevant Government stakeholders. The meetings, workshops and trainings linked to the establishment and rehabilitation of the schemes were all financed by the NGOs.

Commonwealth of Australia (2003) cautions that if donors wish to see benefits sustained, they should on a case by case basis also consider taking on responsibility for contributing to solving operation and maintenance costs problems in a more direct means. That the approach used by the NGOs who rehabilitated the Tsvovani and Dendere schemes lacked materiality and responsiveness as they failed to address the crucial and most important concerns of the farmers they were trying to assist (Accountability, 2005).

Philippa Howell (1998) focuses on a participatory approach in a case study of ActionAid's efforts to promote sustainable and community-based food production in Ethiopia. In order to prepare famine aid in the town of Dalocha, the NGOs utilized local community organizations. Fearing that people might become dependent on handouts, particularly the lowest without means of subsistence, the non-profit arranged loans for

community members so they could purchase blankets and grain. They relied on the assistance of other members of the community. In the analyzed example, the villagers were able to enhance their food production, and 70 percent of the loans were repaid to the NGO, with extensions granted to those who were unable to pay.

Governments are increasingly recognizing Non-Governmental Organizations (NGOs) as formidable forces for social and economic development, significant partners in nation-building and national development, useful forces in supporting the qualitative and quantitative development of democracy, and significant contributors to GDP (Ball and Dunn, 1995).

NGOs can also influence policy changes by lobbying governments. Public advocacy is a key role they can play, and they can help educate the public on vital supply chain issues. Advocacy entails lobbying and focusing on decision-makers, putting pressure on states to adopt policies, and/or pressing states to alter existing policies. Being a "watchdog" can also mean exposing governments to public scrutiny in order to limit abuses of power and promote transparency and accountability. Non-governmental organizations (NGOs) serve a crucial role in fostering public understanding, educating the public, and pointing individuals in the direction of useful government resources. Advocacy encompasses attempts to produce and effect change by influencing decision-makers and governmental policies (Dicklitch, 2001).

2.3.3 Effects of Agricultural infrastructure and sustainability of smallholding mango farming.

2.3.3.1 Effects of Agricultural infrastructure

According to AFDB (2013), one of the most significant obstacles to growth in transitional societies is the lack of infrastructure, which has contributed to the decline in

farm output in rural regions. Agricultural infrastructure has been recommended as a means of coping with such difficulties and in attaining Sustainable Development Goals, and several governments are looking at it as a possible route to lead their countries out of them (SDGs). The seventeen SDGs address three crucial areas of global development: the eradication of poverty, the promotion of shared prosperity, and the protection of the environment, founded on peace and partnerships. The goals outline precise objectives that governments, businesses, and communities should work together to achieve by the year 2030 (UN, 2015).

Thacker et al. (2018) demonstrate that infrastructure has a direct impact on almost 80 percent of the 169 SDG targets. All of the social SDGs can't be achieved without sustainable infrastructure. Since 3.5 billion people are still living below the poverty line, the infrastructure's role in reducing poverty (SDG 1) is vital to global development (Atamanov et al., 2018).

One of the primary goals of infrastructure development is to improve access to essential services. Sustainable agriculture infrastructure that integrates power, transportation, clean water, and sanitation services is strongly correlated with poverty reduction, not only by giving more people with access to these essentials but also by increasing economic opportunities and streamlining communication channels (Bhattacharya et al., 2016).

2.3.3.2 Effects of Agricultural infrastructure to smallholder in Africa

Growing fruit is crucial to people's ability to feed themselves on a national scale. They taste great and provide a lot of health benefits. According to the research of Tewodros Bezu et al. (2014), fruit provides raw materials for domestic industry and has the

potential to earn foreign exchange. Hartono, Irawan, and Irawan, (2010); Hartoyo, (2013) research shows that agricultural infrastructure has significant impacts on the production and productivity of small scale agriculture.

According to Isakson (2014), any country dependent on agriculture stands to benefit greatly from improvements in agricultural infrastructure, which have the potential to transform the current traditional agriculture or smallholder farming into the most modern, commercial, and dynamic farming system possible.

According to Lichter and Brown (2011), the lines between urban and rural areas are blurring due to the increased mobility of people, commodities, and services as well as the disposal of waste and pollution made possible by technological advancements, better roads, higher levels of education, and shifting economic realities. As agricultural revenues decline, rural families must diversify their sources of support to incorporate money from other sources, such as seasonal and permanent migrant remittances. Low-income urban families may buy food and other agricultural products from relatives in the countryside. Urban and rural poverty have both risen as a result of recent changes in the global economic, social, and political setting, such as structural adjustment programs and economic reform (Veltmeyer, Petras & Vieux, 2016). Both urban and rural residents who are net food purchasers stand to profit from lower costs thanks to the findings of Schneider and Gugerty (2011). Accordingly, agricultural production has substantial influence on reducing poverty in addition to its growth benefits. An effective agricultural infrastructure also provides secondary benefits.

Fan et al. (2004) demonstrate that better roads contribute to the growth of small rural non-agricultural industries, such as food processing and marketing companies,

electronic repair shops, transportation and commerce, and restaurant services. Investing in rural infrastructure is a great way to encourage development in those areas. Webster et al. (2013) found that investments in rural areas, such as rural infrastructure, are important for two reasons: (a) they create an environment in which all citizens can enjoy basic living standards; and (b) they provide positive returns to both urban and rural dwellers through better rural-urban linkage.

Additionally, Llanto (2012)'s findings demonstrate that inadequate infrastructure may pose a serious development challenge. The lack of investment in infrastructure and the consequent poor quality of that infrastructure have stifled development. The high cost of conducting business is directly attributable to the state of the underlying infrastructure. This significantly harms the agriculture industry's image and ability to attract new talent. The state of the region's infrastructure directly affects its economic development. The chances for economic growth in a region are hampered when there is a disparity in the availability of infrastructure between different parts of the territory (Crescenzi & Rodrguez and Pose, 2012). Disparities in regional development in Kenya can be traced back to variations in the quality and availability of infrastructure (Manasan & Chatterjee, 2003). Evidence suggests that infrastructure may play a significant role in regional convergence (Cuenca 2004). Investments in productive capital may be limited or reduced due to a lack of confidence in the availability or quality of infrastructure services, which in turn may limit or decrease output (Llanto, 2012).

Andersen and Shimokawa (2007) conclude that problems with transportation, energy, communications, and other related infrastructure lead to domestic markets that don't work well, have little integration across space and time, have low price transmission,

and aren't very competitive on the international level. If emerging nations don't put money into rural infrastructure, it will slow down agricultural and economic growth, which will slow down efforts to reduce poverty. The agriculture sector in developing nations has tremendous potential to contribute to growth and poverty reduction, but this potential is severely hampered by chronic rural infrastructural deficits. As a result of increased agricultural output, higher earnings, and increased non-farm employment, poverty can be reduced through investing in rural infrastructure. Poor people might expect to reap substantial trickle-down advantages (Hazell, 2012).

Aggarwal's (2018) research showed that prosperous rural communities may benefit from the entrepreneurial spirit of their residents by taking advantage of the economic opportunities that are made possible by well-maintained roads. As a result, farmers in rural areas can get access to relatively inexpensive inputs and better pricing for their goods when sold or traded in urban centers. Olsson (2008) observed that road upgrades can affect a community's investment, manufacturing and production system, employment, and transport service supply and demand.

Asher and Novosad (2016) argue that an effective transportation infrastructure can reduce the time and money spent on getting to and from work, which is a major barrier to entering the labor market for many people. In addition to lowering food prices for city people, improved physical infrastructure also encourages rural residents to move to cities in search of better paying jobs. As a result, the well-being of low-income families benefits from infrastructure improvements like new roads and human capital investments like schools (Cameron, Blanusa & Taylor, 2012).

2.3.3.3 Effects of Agricultural infrastructure Regional

Arias et al. (2013) propose that smallholders, with their vast collective experience and intimate understanding of local conditions, possess a number of the practical solutions that can assist in making agriculture more sustainable and egalitarian.

The study by Richardson et al. (2020) on the impact of infrastructure development on agricultural output and employment in the Economic Community of West African States (ECOWAS) found that infrastructures that support agriculture productivity foster employment creation, that access to information and communication technology positively affects agricultural output, and that access to electricity has a positive effect on agricultural employment. The impact of transportation infrastructure on agricultural output was negative and marginal.

Gollin and Rogerson (2014) avers that the upgrading of roads will have far-reaching implications on agricultural output in Sub-Saharan Africa (SSA) countries because agriculture is the foundation of their economies. A mere 34% of rural Africa, compared to 90% of the rest of the globe, has access to roads, according to the African Development Bank (ADB) (African Development Bank, 2010).

2.3.3.4 Effects of Agricultural infrastructure to smallholder Mango farmers

Seid Hussen and Zeru Yimer (2013) point out that the development of the fruit industry will create employment opportunities, especially for farming communities. Furthermore, they contend that investing in agricultural infrastructure might help alter rural economies and alleviate poverty.

Kiprono and Matsumoto (2014) notes that a good road infrastructure can facilitate transportation, hence shortening delivery time and reducing expenses, which can

eventually influence input prices. Farmers' incomes may rise as a result of lower input costs and higher selling prices for their goods.

The ratio of input to output costs will change when input and output costs fluctuate. Inoni and Omotor's (2009) research found that a 2% boost in farmer income and a 12% boost in agricultural production were possible from a 10% improvement in road network quality. All-weather roads are a crucial development strategy that ensures the productivity of agriculture, raising living standards and decreasing poverty, and opening up new economic opportunities (Dercon, 2007).

Dang and Pheng (2015) observed that transportation and communication facilities contribute to the growth of a nation's total agricultural output. Nadeem, Mushtaq, and Javed (2011) discovered that investments in agricultural research and development, irrigation, rural education, and infrastructure (including roads and power) have positive marginal impacts on agricultural productivity increase and rural poverty reduction.

Manalili and Gonzales (2009) found that good road infrastructure and irrigation facilities increase farm profitability and production. Their research shows that the use of nitrogen fertilizer, herbicides, and irrigation all have a positive impact on crop productivity. Urea fertilizer costs more in regions with subpar road infrastructure because of the added expense of transporting the product there. Due of its reduced cost due to cheaper shipping, nitrogen fertilizer is typically used more frequently by farmers. As a result, agricultural output will suffer if money isn't put into building and maintaining infrastructure in rural areas (Poulton & Macartney, 2012).

Arbues, Banos, and Mayor (2015) argue that there are direct and indirect effects of physical infrastructure on agricultural output. Because infrastructure influences agricultural development in several ways, it is possible to categorize it into two groups: water supply and sanitation sectors, and other sectors like irrigation, energy, telecommunications, and transportation. Rural residents' health and productivity are affected by the availability of clean water and sanitary facilities. People in rural areas will be healthier and more productive on the job if they have access to clean drinking water and a sanitary living environment provided by good sanitation infrastructure (Starbird, Norton & Marcus, 2016).

Agricultural output and productivity are affected by institutional infrastructure because it paves the way for the development of institutions like domestic markets and financial institutions that improve access to input and output markets and liquidity and credit for rural residents (Shiferaw, Hellin & Muricho, 2011). Having reliable means of transportation and reliable means of communication makes it much simpler for community-based groups like farmer associations to provide assistance to farmers. As a result of improved transportation, farmers can save money on inputs and save time marketing their products. Communication between buyers and sellers is facilitated by increased connectivity, which in turn opens the door to potentially lucrative new opportunities (Hajir, Obeidat, Al-dalahmeh, & Masa'deh, 2015).

Musyoka, Kennedy & Isaboke, Hezron (2020) established that access to storage facilities by small-scale mango producers boosts the product's availability for a longer period of time, resulting in higher pricing on the market, particularly during times of high demand. Farmers that have formed cooperatives have a better opportunity to learn about value addition, share ideas, and reap the rewards of doing so. The training of

farmers on value addition also improves farmers' knowledge, abilities, and motivation to engage in value addition.

Akkoyunlu (2015) and Ndabeni (2016) observed that rural infrastructure develops physical connectivity and promotes better integration of rural and agriculture areas with developing urban markets, which are in turn linked to global trading markets, hence driving economic growth and providing prospects for poverty reduction in those areas. Residents of both urban and rural areas who are net food purchasers will profit from the rising agricultural productivity that drives down food prices. Accordingly, agricultural production has substantial influence on reducing poverty in addition to its growth benefits.

In addition to investments in physical infrastructure such as roads, electricity generation, irrigation facilities, and telecommunications, the campaign must involve efforts to create and implement new rural institutions, strengthen domestic rural markets for inputs, outputs, and capital, generate appropriate technologies for small-scale farmers, facilitate non-agricultural firms in rural areas, and eliminate trade damaging OECD agriculture policies. Investing in rural infrastructure is expected to yield a significant return for society economically (Stromquist and Monkman) (2014).

Trienekens (2011) emphasized the importance of having access to low-cost physical infrastructure as a factor in agriculture value chain competitiveness. Infrastructure that supports on-farm production, such as irrigation, energy, transportation, and pre- and post-harvest storage, assures efficient trading and exchange, such as covered markets and telecommunications, provides value to the domestic economy, such as geo-processing and packaging facilities, and enables food to travel quickly and effectively

from the farm gate to processing facilities, then on to wholesalers, is included in this category (transportation and bulk storage).

2.3.4 Challenges on the use of agricultural infrastructure on sustainable smallholder mango farming.

The productivity of smallholder agriculture and its contribution to food security and poverty reduction are dependent on the services supplied by well-functioning ecosystems, such as agricultural infrastructure, soil fertility, freshwater delivery, pollination, and insect control, among others (IFAD (2011a).

In recognition of the crucial role that family farmers play in ensuring global food security, socio-ecological sustainability, and fair economic growth, the United Nations proclaimed 2014 as the "International Year of Family Farming" (FAO, 2014). Further, they argue that effective rural community development is necessary to maintain these gains over the long term, as both the scarcity of agriculturally productive land and the need to reduce the loss and degradation of natural environments necessitate greater efficiency gains in the use of resources. There are a variety of approaches that have been offered to bring about sustainability in agriculture on a small scale, particularly in the poor countries. Technical, institutional, political, socioeconomic, and environmental approaches could all be part of the solution.

Smallholder farmers in rural areas could benefit much from growing mango. This potential has not been fully realized. Gaining access to this potential calls for cooperation amongst all parties along the value chain, from growers and producers to shippers and manufacturers, retailers and wholesalers. It's not easy to maximize output

throughout the entire mango supply chain. Lack of goodwill in allowing farmers to concentrate on mango farming, lack of improved seedlings that are economically viable, improved farming training procedures, correct agricultural inputs, mitigating weather effects, and well-organized marketing away from the hands of brokers as a tool that greatly contributes to the income of the smallholder farmer are all difficulties facing the farming business.

Hazell (2012) notes that the livelihoods, food security, and productivity of smallholder mango producers are threatened by a complex set of interconnected risks and difficulties. Lack of human capital and restricted access to infrastructure, markets, and technologies are just two examples of the difficulties smallholders face in making a living. Mango producers, especially those on smaller plots of land, are feeling the effects of a wide range of new climate, health, price, and financial risks and problems. The occurrence of such shocks not only threatens existing fragile food production systems, but also makes certain smallholders more risk averse and inclined to pursue more subsistence-oriented activities, leading to a continuation of smallholder poverty and a shortage of mango for export.

AGRA (2017) observed that low levels of productivity and external shocks like climate change are exacerbated by the insecurity of land tenure and unequal access to land, restricted access to markets, finance, high-yielding seeds, farm inputs, and automation experienced by smallholders. Another key obstacle to Africa's agricultural growth and development is the continent's dreadfully inadequate infrastructure. The FAO reports that farmers face challenges delivering inputs and produce since less than half of the rural population resides near appropriate roadways (FAO, 2014). The United States Department of State estimates that one-third of the world's agricultural output is either

lost or spoiled during transport because of inadequate storage facilities on the African continent. There is little doubt that improving agricultural infrastructure is crucial to resolving some of the world's most pressing problems and reducing waste on farms.

Arias et al. (2013) believe that smallholder agriculture is characterized by modest production volumes of variable quality, which are a result of restricted access to inputs and money, low levels of investment, and limited access to knowledge of improved agricultural technology and practices. They went on to say that small farmers are prevented from investing in more efficient new technologies that would allow them to raise surpluses to sell on the market because of the high levels of pricing risk, production risk, and uncertainty and the lack of instruments available to manage them. It is difficult to generate a surplus that can be sold because of factors such as poor infrastructure, expensive storage and transportation costs, and uncompetitive marketplaces.

FSD (2015) discovered that numerous farmers acquire planting supplies from uncertified sources. Most farmers have taught themselves how to graft mango trees, despite the fact that doing so with outdated methods can be harmful to the trees' long-term health and productivity. Only 19% of farmers, mostly commercial growers, bought their planting materials from approved nurseries. The other 81% either grafted their own mango trees or let their own seedlings grow. The research also showed that many farmers do not fertilize or spray their mango trees as frequently as they should (4 to 6 times a year), with the main excuses being a lack of financial resources and a lack of convenient locations to store the equipment.

Kehlenbeck et al. (2012) state that farmers risk losing money if they don't have access to affordable inputs like chemical treatments for the new cultivars' susceptibility to

diseases and pests (Kehlenbeck et al. 2012). In contrast, local landraces have a better chance of surviving in their native environments, and they are more resistant to pests and diseases and drought (Sennhenn et al., 2013). Mangoes grown in Kenya are small and heavy in fiber content, which reduces their market demand despite the fact that native landraces often have good yields even without employing external inputs. This could result in a loss of genetic resources, such as characteristics for resistance against biotic and abiotic challenges, as farmers switch from growing native small-fruited mangoes to growing improved or alien cultivars (Sennhenn et al., 2013).

Post – harvest Challenges

The substantial postharvest losses are another major obstacle in the mango value chain. One study found that as much as 50 percent of all mangoes never make it to consumers due to spoilage in the supply chain. Although farmers are using a variety of tactics to cut down on their losses and boost the industry's bottom line, manure farming still isn't a very profitable endeavor (Hazell, 2012).

Alexandratos and Bruinsma (2012) assert that post-harvest losses, which can occur at any point between harvest and consumption, are one of the most important factors influencing food supply and, consequently, food costs. In order to reduce waste, boost crop profits or nutritional value, and guarantee safe food production, they advocate for the use of on-site storage and minimal-scale processing facilities. Lack of market exchanges and auction centers to increase margins for farmers and farmer cooperatives and to bring economies of scale to the provision of seeds, fertilizers, and other agricultural inputs is another key restraint on agricultural development. Lack of adequate agro-processing capacity to meet the quantity, quality, and consistency standards set by distributors and retailers (Asoegwu, 2018).

The removal of market inefficiencies, creation of an enabling environment for market participation and entrepreneurship, and stimulation of innovation are all essential elements of a stable and supportive policy and regulatory framework for the agriculture sector. Reforming the property system and the irrigation sector, encouraging investments in productivity-enhancing technologies, recognizing female and male producers, enhancing transport services, strengthening integrated water resource management and other infrastructure to link markets and reduce transactions costs, expanding access to information and financing, and bolstering the capacity of agricultural households and their associations are all necessary first steps.

According to the Food and Agriculture Organization (FAO, 2014), export-oriented tropical fruit farms in poor nations earned $12.8 billion in 2010. Small-scale tropical fruit growers have been excluded from value chains due to a lack of economies of scale, the difficulty of meeting market access standards, poor market links, and insufficient market information and distribution. Weak farming methods, aging trees, lack of superior varieties, poor marketing structures resulting in up to 40 percent annual yield losses, and a lack of value-adding technology are other challenges that limit mango production and marketing.

Low levels of investment in irrigation are a significant limitation for rain-fed agriculture. Numerous farmers and farmer cooperatives that operate independently are unable to develop irrigation systems due to the high initial cost and lengthy payback period. In addition, the commercial viability of such investment decisions frequently depends on the expansion of agricultural production in the future, which may be constrained by factors such as the availability of land, the cost or dependability of inputs, and other aspects of infrastructure provision, such as road quality and transportation costs. This calls into question the coordination and sequencing of

infrastructure: for instance, the importance of reliable and affordable electricity to support investments in lift irrigation or geo-processing and cold storage, and the need to upgrade rural roads by investing in geo-processing facilities that rely on regular deliveries of raw materials from out growers (Vashchyk, (2012); Asoegwu, (2018).

Infrastructure Challenges

Challies and Murray (2011) assert that the cost of infrastructure to support production on farms, allow for efficient trading and exchange, add value through processing, and move produce from the farm gate to the processing facility and then to wholesalers is a big part of how competitive agricultural value chains are. Lenz, Munyehirwe, Peters, and Sievert (2017) indicate that the biggest barrier to the expansion of agribusinesses is a lack of access to infrastructural services. Without an increase in agricultural production, a substantial increase in producer incomes is possible if the expenses of storing, trading, and transporting harvested goods can be decreased.

Mdlalose (2016) found that in many sections of sub-Saharan Africa, as well as in the more remote rural regions of Southeast Asia and Latin America, rural roads are insufficient to connect smallholders to local marketplaces or agribusiness processors. Wet season road closures, for instance, can force farmers to sell their harvest at a loss during the dry season. As a result, wet-season prices rise, and small farmers are unable to capitalize on this trend. Morganti (2011) stated that road quality also has a role. Produce must be transported by bulk or refrigeration to reach international markets and some metropolitan markets.

Bhatasara's (2011) research showed that the resettled farms' infrastructure is in a bad way. The Zimbabwean government's fast-track land reform initiative had a severe

impact on farm infrastructure and equipment. Therefore, infrastructure investment is essential to ensure agricultural productivity.

According to Paul and Steinbrecher (2013), inadequate access to infrastructural services is the greatest barrier to the expansion of agribusinesses. Due to low population concentrations, distant areas, and weather-dependent production systems, private sector participation in agricultural infrastructure is extremely hazardous. The continuing problem appears to be determining when and when public-private partnerships (PPPs) are a value-added proposal for infrastructure in market-oriented agricultural development, as well as how to best organize the financial and institutional frameworks for such collaboration.

Production challenges

Farmers are susceptible to environmental change, especially climatic change. Climate change and the resulting rise in world average temperatures, as well as an increase in the unpredictability of precipitation, will have dramatic effects on agriculture in the twenty-first century and will eventually damage smallholder production methods. Climate change is associated with extreme anomalies in meteorological events (Hansen, Sato, and Ruedy, 2012) as well as greater variability and unpredictability in rainfall, which may have more severe implications than climate change itself. Extreme weather occurrences include extreme heat waves, torrential downpours, and droughts.

Cline (2007) and Gornall et al. (2010) estimate that agricultural production would decline in a large portion of the developing world, with projections for East Africa suggesting that changes may not necessarily be uniform within and within nations. Climate change and environmental degradation also make it hard for farmers to make a living. This is because changing weather patterns and a higher risk of shocks will make

it harder for farmers to make a living in the future. For example, the rainy season, which many farmers depend on, will become less predictable (Buckingham and Turner, 2008; Leichenko and O'Brien, 2008; Tingem et al., 2008). (2008). In addition, diminishing soil fertility as a result of over-cropping and irresponsible use of chemical inputs increases farmers' vulnerability (Gosh, 2004). Presently, land degradation, population increase, and climate change provide a formidable obstacle to sustainable livelihoods and food security in emerging nations (Tingam et al 2008).

Since the mid-1990s, soil degradation is predicted to have lowered worldwide agricultural productivity by 13%. (Wood, Sebastian and Scherr 2000). Africa was perhaps the continent most affected by land degradation (Nellemann et al., 2009), which affected between 1 and 8 percent of the world's land. In their review, Nellemann et al. (2009, p. 40) stated, "Satellite measurements indicate that between 1981 and 2003, there was a reduction in the productive land area (as Net Primary Productivity) throughout 12 percent of the world's land area. The impacted regions are home to between one and one and a half billion people, or 15 to 20 percent of the world's population...." In certain sub-Saharan African nations, farmland production dropped by more than 40 percent over the course of two decades, while the population doubled. Africa's yield loss owing to historical soil erosion may range from 2% to 40%, with a mean loss of 8.2% across the continent (Nellemann et al. 2009). Degradation can be linked to agricultural intensity or the proportion of land used for agriculture. Smallholders in Ethiopia's highlands benefit from rich soils and abundant precipitation. However, rising intensification and continuous agriculture on sloping lands, without supplemental application of soil amendments and conservation methods, resulted in an average of 42 tons/ha/year of nutrient depletion and soil erosion, with individual fields exceeding 300 tons/ha/year.

Agriculture is the largest global consumer of water resources and, in irrigated areas in particular, influences both the quality and quantity of water, as well as causing soil salinization and waterlogging. Large portions of the developing world are already subject to high levels of agricultural water stress, where water supplies are frequently limited but agricultural needs are high and where insufficient quantities of clean water limit agricultural production (Cassman et al. 2005).

Along the value chain, the mango sector in Kenya faces several obstacles. Lack of certified true-to-type seedlings, pests and illnesses (mostly fruit fly and seed weevils), inadequate agronomic techniques, and the production of multiple varieties under small-scale production systems are the primary concerns at the production level. Inadequate harvesting maturity is an added obstacle for quality-focused mango growers. Since buyers often purchase fruit on-tree and arrange for their own teams to enter the orchards to harvest the fruit, they tend to pluck fruit in an immature state if markets are in limited supply and to leave fruit on the trees over its ideal maturity date if markets are oversupplied.

The post-production issues include high post-harvest losses (estimated at 40 percent) and numerous logistical issues revolving around produce aggregation, poor infrastructure, high transport costs, lack of standards for mangoes, poor post-harvest handling, insufficient supplies to processing industry, lack of market intelligence, and high price volatility. On the export front, Kenya has tended to rely on a single niche market, the Middle East. The industry lacks packaging regulations for mangoes, and a considerable portion of the crop is transported in open trucks, resulting in fruit damage and contributing to post-harvest losses. While the packing and transit rules are outlined

in K S1758, they are not consistently enforced. In addition to harvesting fruit at the incorrect ripeness, as previously indicated, the key contributors to post-harvest losses are poor transit conditions, inadequate storage facilities, mango seed weevil and fruit-fly damage, and poor coordination between harvest and markets. The rain-fed nature of production adds to seasonal commerce and processing of mangoes. Kenya has an edge, though, because the coastal region has two planting seasons and processors have access to Ngowe and Apple mango for up to nine months of the year. Inefficient export operations at the port of Mombasa force exporters to adopt the more expensive air-freight option. The sector has not invested in standards such as Global Gap, which includes traceability concerns, making it impossible to join the European market, whether in fresh or processed form. In terms of value addition, processors are running between 35 and 40 percent of their capacity due to a lack of a consistent supply of traceable, certified mangoes (Bhatasara (2011).

2.4 Theoretical Framework

Various theories are applied in understanding agricultural infrastructure and sustainability of small holder farming. This study was guided by the sustainable livelihood theory.

2. 4 .1 Sustainable Livelihood Framework

The framework adopted in this study is the Sustainable Livelihood Framework by the Department for International Development (DFID, 1999). This theory was propounded by Chambers and Conway (1992). According to these scholars, sustainable livelihood is an attempt to go beyond the conventional perspectives and approaches in handling poverty eradication. This framework is useful for understanding how underlying constraints affect livelihoods and access to livelihood resources as well as

understanding the roles and dynamics of institutions in providing an enabling environment for sustainable livelihoods. The concept of 'sustainable livelihoods' was first introduced by the Brundtland Commission on Environment and Development and then further expanded by The United Nations Conference on Environment and Development in 1992 (Krantz, 2001). Since then, a number of international agencies have adapted different models/approaches based on the concept (GLOPP, 2008).

DFID _Sustainable Livelihood Framework' (SLF) is one of the most widely used livelihoods frameworks in development practice. The DFID, in 1997, adopted the Chambers and Conway's definition of livelihoods:

> *"A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base"* (Chambers and Conway, 1997; DFID, 2000).

DFID aims at the elimination of poverty in poorer countries by emphasizing ways of applying livelihoods approaches. The livelihoods approach is flexible and adaptable to specific local settings and to objectives defined in participatory manner. The DFID Sustainable Livelihood Approach is based on the following principles. The approach is people-centered; people rather than the resources are the priority concern. Secondly, the approach is holistic in nature thereby understanding the stakeholders' livelihoods as a whole. Thirdly, the approach is highly dynamic in order to learn from changes and help mitigating negative impacts, whilst supporting positive effects. Fourthly, central to the approach is the recognition of everyone's inherent potential for removal of constraints and realization of potentials. Identifying these strengths rather than the needs and problems is the starting point to contribute to the stakeholders' robustness and ability to achieve their own objectives. Fifthly, the approach tries to bridge the gap in stressing the links between the two levels. As people are affected from decisions at the macro

policy level and vice-versa, the macro-micro relation needs to be considered in order to achieve sustainable development (Kollmair *et al*., 2002).

The Sustainable Livelihood Framework comprises of the vulnerability context. This frames the external environment in which people exist. Includes critical trends, shocks and seasonality, over which people have limited or no control, yet they have a great influence on livelihoods and on the wider availability of assets. Vulnerability exists where people face harmful threat or shock with inadequate capacity to respond effectively. The element is livelihood assets/capitals, which refers to an accurate and realistic understanding of people's strengths (assets or capitals). It analyses how people convert their strengths into positive livelihood outcomes. The assumption made is that people require a range of assets to achieve positive livelihood outcomes. The SLF identifies five types of assets or capitals upon which livelihoods are built, that is, human capital, social capital, natural capital, physical capital and financial capital (DFID, 2000).

Critical to this study is the incorporation of policies, institutions and processes that operate at all levels and effectively determine access (to various types of capital, to livelihood strategies and to decision-making bodies and source of influence), terms of exchange between different types of capitals, and returns to any given livelihood strategy. Policies, institutions and processes have a direct impact upon a feeling of inclusion and well-being. Policies, institutions and processes can determine access to assets and influence decision making processes (DFID, 2000).

The Livelihood strategies which comprise the range and combination of activities and choices that people make to achieve their livelihood goals. It is a dynamic process in which people combine activities to meet their various needs at different times. Different

members of a household might live and work at different places, temporarily or permanent (DFID, 2000). Livelihood strategies are directly dependent on asset status, policies, institutions and processes. Poor people compete and the livelihood strategy of one household might have an impact (positive or negative) on the livelihood strategy of another household (DFID, 1999). The study is informed by the livelihood outcomes which are the achievements or outputs of livelihood strategies that include income, increased well-being, reduced vulnerability, improved food security and a more sustainable use of natural resources (DFID, 2000).

For the purpose of this study, the DFID's Sustainable Livelihood Framework was adapted, modified and used. The framework as illustrated in Figure 2.1 is in five parts namely the Vulnerability Context, Livelihood Assets, Organisations and Institutions, Livelihood Strategies, and Livelihood Outcomes.

The mango farmers in the study area are confronted with vulnerable situations and opportunities in the new livelihood activity (mango farming). The vulnerable situations in this context include drought, landslides, pest attacks, conflict, diseases and absolute poverty which have led to unemployment, low productivity and low incomes. The opportunities in this study are in the form of employment generations and higher income associated with mango farming activities. In the context of these vulnerabilities/opportunities, the mango farmers can adopt available livelihood assets (Physical, input based, resource based and institutional infrastructure) to engage in the activities of mango farming. The role of stakeholders on the implementation of mango farming is important towards scaling income and reducing poverty for small-holder farmers while improving the market access for small-holder farmers. Government and other institutions play a key role to ensure that the farmers access the required inputs, training and information through the support system. The county government makes

laws, rules and policies to regulate the activities of mango farming and ensure sustainability while the private sectors provides both the tangible resources like seedlings and fertilizer and intangible resources like capacity building and skills. Well established laws, policies and structures aid in achievement of agricultural sustainability which in the long run leads to livelihood outcome which encompasses more income, increased wellbeing, reduced vulnerability, improved food security and more use of natural resources.

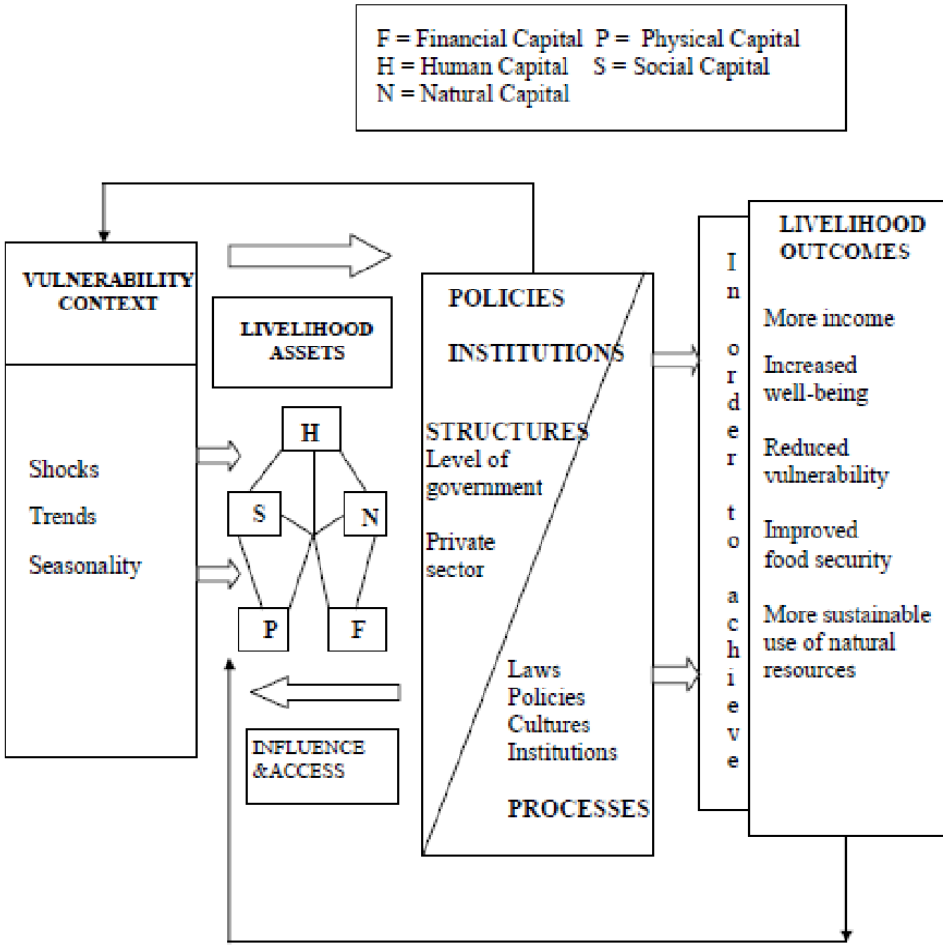


Figure 2. 1: The sustainable Livelihood Framework.

***Source*: DFID (2000)**

F = Financial Capital S = Social Capital
P = Physical Capital N = Natural Capital
H = Human Capital

2.5 Conceptual Framework

The Conceptual framework conceptualizes the relationship between the research variables in the study. It also helps the reader to quickly see the proposed relationship.

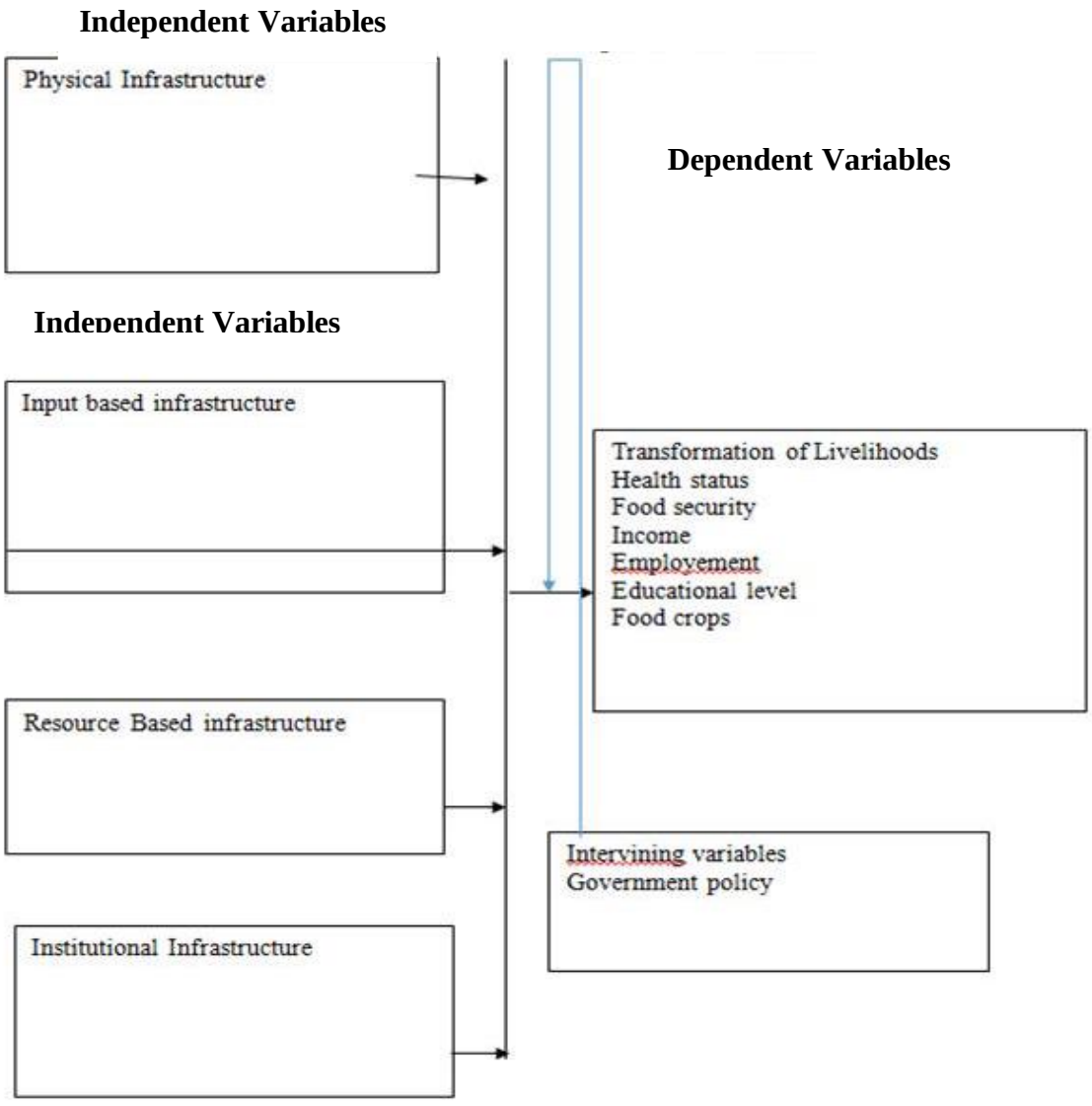


Figure 2.2: Conceptual Framework

A conception of the study is shown in Figure 2:2. Physical infrastructure (road connectivity, transport, storage, processing, and preservation), input-based infrastructure (seed, fertilizer, pesticides, and farm machinery), resource-based infrastructure (irrigation facilities, farm power/energy), and institutional infrastructure are all conceptualized as the independent variable (agricultural research, extension and

education technology services, information and communication services, financial and marketing services). Agricultural sustainability is considered as the dependent variable. Factors in the government that influence policy that control the mango farming process are examples of intervening variables. There is a need for appropriate policies and legislation for the acquisition and adoption of green techniques and technologies. The Constitution and the laws needed to create a comprehensive legal framework for addressing the unique difficulties encountered by small holder mango producers.

Infrastructure on a physical level is needed by farmers to support mango cultivation activities. To improve the output's quality and quantity, they also need infrastructure that is based on input. In addition, they require infrastructure based on resources to support the mango crop. Additionally, institutional infrastructure is needed by mango producers to support production activities. Adopting these agricultural infrastructures will enhance output, transforming livelihoods by producing high incomes, food security, jobs, increased food production, and higher levels of education.

2.6 Literature Review Gap

Inadequacies in transportation, energy, telecommunications, and related infrastructure result in poorly functioning internal markets with limited geographical and temporal integration, low price transmission, and poor international competitiveness. Despite the well-documented importance of agriculture infrastructure to promote growth and alleviate poverty, the high economic returns on investments in agricultural infrastructure, and the significant deficiencies of rural infrastructure in the majority of developing countries, neither national nor international aid agencies appear to prioritize investments in the construction of new infrastructure and maintenance of existing infrastructure. The majority of infrastructure investments must come from the public

sector, while public-private partnerships should be considered when appropriate. Despite the growing number of studies in the field of agriculture infrastructure and the sustainability of livelihoods, most of them are regional or worldwide in scope; therefore, this study will attempt to fill this void**.**

2.7 Chapter Summary

This chapter sought to provide a detailed analysis of the relevant available literature on the main concepts on the agricultural infrastructure on sustainability of smallholder farming and it is evident that agricultural infrastructure should play a greater role in trying to alleviate poverty and in food provision especially in rural areas.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter presented the process involved in carrying out a study on agricultural infrastructure and its implications on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya. Key areas discussed included: study area, research philosophy, research design, research approach, target population, sample procedure and sample size, data collection instruments, validity and reliability of research instruments, methods of data analysis and presentation and lastly, ethical consideration.

3.2 Study Area

The study area was in Elgeyo Marakwet, Kenya, which is one of the counties in the North Rift. Elgeyo Marakwet County covers a total area of 3029.6 km^2 which constitutes 0.4 percent of Kenya's total area. It extends from latitude 0 20′ to 1o 30′ to the North and longitude 35o 0′ to 35o 45′ to the East. It borders West Pokot County to the North, Baringo County to the East, Trans Nzoia County to the Northwest and Uasin Gishu County to the West. The county has an elongated shape and it is wedged in between the Uasin Gishu Plateau to the West and the Kerio River to the East. The Kerio River has its source in the southern highlands of the county and drains into Lake Turkana (CIDP, 2018-2022).

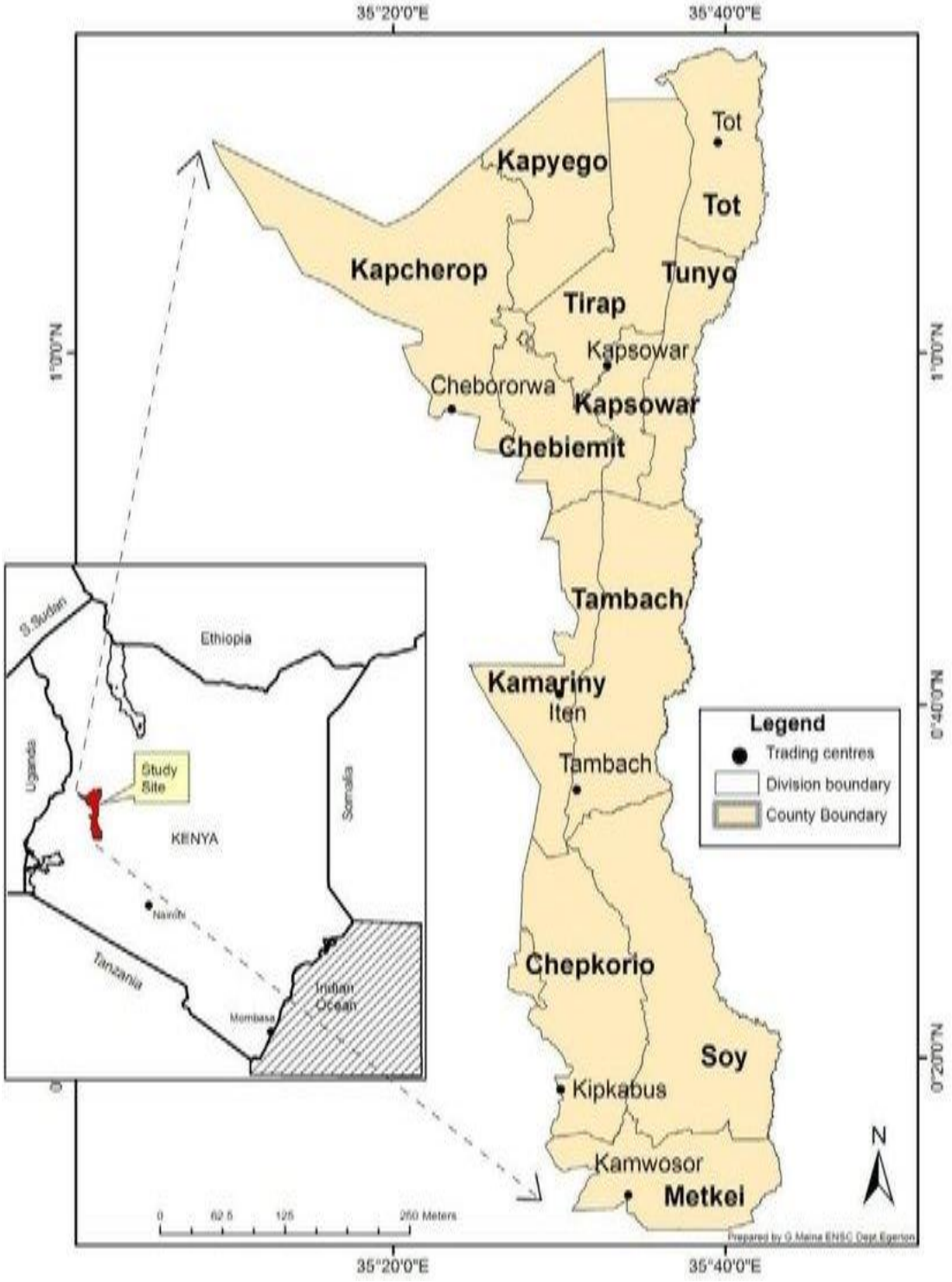


Figure 3. 1: Study area map

3.2.1 Population Density and Settlement

Ngechu (2004) defined a population as a well-defined or set of people, services, elements, and events, group of things or households that are being investigated. The county's total population was 369,998 according to the 2019 National Population and Housing Census. The county has four constituencies and Keiyo South has the highest population of 148,193 while Keiyo North has the lowest population of 100,074. On the other hand, Marakwet West has a population of 147,126 while Marakwet East has 106,908 according to 2018 population projections. There are variations in population distributions and densities within the county with the average density being 166 persons per km2. Keiyo North has the highest population density of 185 persons per km^2 while Marakwet East has the lowest with 136 persons per km^2. The high density in Keiyo North could be attributed to it being largely on the Highlands geographic area thus having favourable climatic conditions and fairly developed infrastructure, given that the county headquarters is situated in this sub-county, whereas Marakwet East's low density could be attributed to the poor infrastructural facilities, insecurity with bordering Counties and unfavorable climatic conditions in the Sub-county.

Elgeyo Marakwet County, which has its Headquarters in Iten, is inhabited by two major communities, Keiyo and Marakwet, minority communities of Sengwer and other small communities. All the communities occupy unique locations defined by the distinct ecological zones in the county, i.e. the highland, the escarpment and the Kerio Valley (CIDP, 2018-2022).Generally, there is a denser settlement on the agriculturally rich highlands and arable parts of the escarpment with most patterns concentrating on major facilities like roads, urban centers and schools. The lowlands/valley majorly exhibit sparse settlement patterns.

3.2.2 Physical and Topographic features

According to the CIDP (2018-2022), the county is divided into three topographic zones namely: Highlands, Kerio Valley and Escarpment: all of them separated by the conspicuous Elgeyo escarpment. Each of the three zones has attracted a different settlement pattern. The Highlands, which constitute 49 percent of the county area, is densely populated due to its endowment with fertile soils and reliable rainfall. The Escarpment and the Kerio Valley make up 11 percent and 40 percent respectively. These areas have low rainfall and are prone to natural disasters such as drought and landslides. Due to these harsh climatic conditions coupled with high cases of insecurity, these areas have high poverty levels and sparse populations. The study concentrated on Egeiyo Marakwet county specifically the three Wards Endo Ward, Arror Ward and Soy North ward respectively.

3.2.3 Climatic Conditions

According to Elgeyo Marakwet County Meteorological Department (2018**)** the County has a relatively cool climate with varied rainfall levels across the County. This is because of the geomorphology/topography that is characterized by three distinct agro-ecological zones namely the highlands to the west, the escarpment (hanging valley) and the lowlands (valley) to the east. The variation in altitude from 900m above sea level in the Kerio Valley to over 3000m above sea level in the highlands gives rise to considerable differences in climatic conditions. The annual mean temperatures on the highland range from 18^{o}C– 22^{o}C while down in the valley, it ranges from 25^{o} C – 28^{o} C. The average annual rainfall in the county ranges from 700 mm in the semi-arid Kerio valley to 1700 mm on the Keiyo and Marakwet highlands (Cherangany Hills). The County thus shows a trend of decreasing rainfall from west to east. It is the eastern

lowlands of the county that exhibit lower and less reliable rainfall as well as being a part of the county that is most at risk of drought and floods.

3.2.3 Economic Factors and Land Holding

Economic activity in the county is characterized by mixed farming, which consists mainly of livestock and subsistence farming. Other activities include small business, tourism and fluorspar mining in Kerio Valley. Agriculture is the backbone of the county's economy with more than 80 % of the population engaging in farming and related activities. Additionally, the County produces both food and cash crops that vary with the agro-ecological zones. The major food crops include maize, beans, wheat, bananas, green grams, groundnuts, sorghum, millet and cowpeas. Horticultural and industrial crops which are mostly grown for sale include Irish potatoes, avocado, passion, mangoes, watermelon, papaws and pyrethrum.

The CIDP 2018-2020, indicates that the average holding size in the county is 7.0 Ha with the small scale farming acreage of 1.36 Hectares. The total acreage under food crop farming is 88,639.3 Ha whereas that under cash crop farming covers 4,003.74 Ha. Most land in the highlands is used for crop farming and dairy husbandry whereas the land in the Valley and the escarpment is used for livestock rearing and mango farming. The proportion of land owners with title deeds in the county is 52.5 % with the majority being found in the highlands. Most of the land in the escarpment and the Valley does not have title deeds since most of it is communally owned.

3.2.4 Characteristics of the Study Area

The study was conducted in specific mango growing wards in the county this include Endo ward in Elgeyo Marakwet East sub county, Arror ward in Marakwet West sub County and Soy North ward ward Keiyo South Sub County, Elgeyo Marakwet County,

Kenya. The County has three distinct topographical zones: the Highlands, the Escarpment, and the Valley. The Highlands are suitable for dairy cows, sheep for wool, potatoes, maize, wheat, and beans production. Down the escarpments, there is cultivation of maize, millet, sorghum and beans even with high risk of soil erosion, landslides and rock falls. While in the Valley, the farmers keep zebu cattle, poultry, goats and sheep; practice horticulture, millet, sorghum, groundnuts and green grams. Most of the farmers are smallholders with an average of 1.36 ha; the few large-scale farmers have an average of 17.3 ha (CIDP 2018-2020).

The Highlands are more densely populated compared to the Lowlands and the Escarpments due to better conditions for agriculture. Noticeably, different types of climatic conditions and hazards are experienced in the different zones. The main climatic hazards for the Highlands are uncertainty in season and frost. Heavy rainfall events in the Escarpments have caused soil erosion due to runoff and landslides in extreme cases. The lowlands experience prolonged droughts resulting in crop failure, and scarcity of fodder and water hence affecting the livelihoods. The other extreme event is floods, which cause silt and sedimentation of rivers and streams due to heavy rains in the Highlands.

3.3 Research Philosophy

The study employed pragmatic philosophical underpinning. It was relevant in the study because pragmatism focuses on solving the current problems through comparison of the existing solutions and the proposed solution as proposed by Goldkuhl (2012). Pragmatism from the perspective of Jack, Norman & Hellen, (2012) is that it uses what it works in given situations and that it focuses on action, change, and the interplay between knowledge and action. In this regard, pragmatism promotes research aiming at providing solutions or interventions to human problems (Ven, 2007). Transmission of

livelihoods like those of small scale mango farmers involves the collection of different ideas and knowledge on the current needs of the farmer's versus the revenue capabilities, from mango farming to adopt competitive agricultural infrastructure that leads to sustainable agriculture.

Additionally, in line with agricultural infrastructure, pragmatism advocates for application of practices that work best, by encouraging agricultural infrastructure which will contribute to suitability in mango farming among the smallholders farmers. Further, pragmatism was suitable because it is a philosophical underpinning for mixed methods studies; it is not fixed to any one system since it draws freely from both qualitative and quantitative assumptions. It allowed the researcher t to choose the approaches, techniques and procedures that sufficiently guided the conduct of inquiry into agriculture infrastructure for sustainable farming. In addition, Pragmatic philosophy has its priorities on the practicality and application of research, to solve human problems. The pragmatic theory insists on constant empirical verification of phenomena in order to ascertain the legitimacy of facts, since it is only through such investigations that the intricacies surrounding practices and processes can be unraveled (Nyametso, 2010).

3.4 Research Design

Research design is defined as a strategic framework for action that serves as a bridge between research questions and the execution, or implementation of the research strategy. It is an action and a procedure for conducting a study which spans the decision from broad assumptions to detailed methods of data collection and analysis. It signifies the arrangements, conditions for collecting and analyzing of data with a goal of combining

significance to the research purpose. (Creswell, J. W., & Plano Clark, V. L., 2011). Research design constitutes the outline for the collection, measurement, and analysis of data. To achieve the study objectives and address the research problem, this study adopted a mixed method approach.

In the context of mixed method approach, the study adopted a cross -sectional survey research design. This design involves drawing a sample of elements of the population of interests. It is appropriate since it attempts to describe the characteristics of a large population, making use of large samples, hence making results significant statistically when analyzing multiple variables. Cross-sectional survey design allows use of different methods of data collection like questionnaires and interviews. It is also suitable for descriptive studies and gives a description of the state of affairs as it exists. Data from the questionnaires, FGD and interview were conducted separately yet concurrently and the findings were integrated during the interpretation phase(Triangulation) of the study and equal priority was given to both types of research as proposed by (Creswell, J. W., & Plano Clark, V. L., 2011). This is suitable in obtaining factual and attitudinal information in answering research questions. Cross - sectional survey design through the use Triangulation was found appropriate for this study since it attempts to describe a more complete understanding of a phenomenon of what is in pastoral and rural setting of Elgeyo Marakwet. It also allowed cross-validation or corroboration of the findings, provides well-validated and substantiated findings.

3.5 Research Approach

This study adopted a mixed method approach which included both quantitative and qualitative approaches. Quantitative approach is characterized by an objective positivist search for singular truths that relies on hypothesis, variables and statistics while qualitative approach rejects positivist rule and accepts multiple realities through the study of in depth cases and can be accessed as being subjective (Creswell, (2008) and Neuman, (2005). The advantage of adopting this strategy was that the biases of the quantitative and qualitative approaches were minimised (Greene, 2008). Due to the complexity of issues involved in the rural agricultural, a pluralistic method, and for that matter a mixed research approach was deemed to be the ideal research approach. It was necessary to adopt a method which enables generalizations to be made, while at the same time facilitating rich descriptive texts. In addition, the mixed research approach was considered desirable because it allowed complicated issues to be exhaustively investigated, interpreted and disseminated within the relatively short period allocated for the present research.

3.6 Target Population

The target population of this study was mainly the small holder mango farmers in Elgeyo Marakwet County, more specifically Endo ward, Arror ward and Soy North ward. In addition, the study also targeted key informants which included County crop manager, County Agricultural officer, Cheptebo farm manager, Tot factor manager, KVDA agricultural representative, 3 wards agricultural officer and 2 transporters.

3.7 Sample Size Procedure and Sample Size

Sampling means selecting a given number of subjects from a defined population as a representative of that population. Sampling is the procedure a researcher uses to gather

people, or things to study. It is a process of selecting a number of individuals or objects from a population such that the selected group contains elements representative of the characteristics found in the entire group (Orodho and Kombo, 2002).

3.7.1 Sample Size

The sample size of the mango farmers was determined based on Robert V. Krejcie and Daryle W. Morgan's table (1970) as shown in figure 3.2.

N	*S*	*N*	*S*	*N*	*S*
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

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

Figure 3. 2: Sample Size

According to CIDP the total number of mango farmers in in the selected wards is estimated to be 9200. Based on the above table, one uses the total population (N) to determine the corresponding sample size (n) that is already predetermined, therefore a sample size of 370 was drawn from the population. The study gathered field data from mango farmers and in addition, 10 key informants were interviewed while traders and farmers, 10 from each ward Endo, Arror and Soy North formed the Focus Group Discussion.

3.7.2 Sampling Techniques and Procedures

The study employed simple random and purposive sampling techniques. Using data on the households, the study adopted Simple random technique to select small holder mango farmers in Endo, Arror and Soy North respectively. In simple random sampling method, each member of the population under study had an equal chance of being selected. Bias was avoided, because there was a high probability that all the population characteristics were represented in the sample. The study also utilized the purposive sampling method to select key informants who were believed to be resourceful by virtue of possessing information crucial to the achievement of the study objectives. This method was employed in the identification of the various government actors and non-state actor's representatives. Information gathered, was used to corroborate data collected from the small holder mango farmers.

3.8 Methods of Data Collection

The study adopted both qualitative and quantitative processes of data collection which was done in sequence. The following methods of data collections were adopted: Survey Method, questionnaires, interviews, Focus group discussions, Key Informants interview, and review of the literature.

3.8.2 Survey Method.

Survey was the main method of data collection. It involves collection of data from the 370 households in Elgeyo Marakwet County. Data collection surveys collect information from a targeted group of people about their opinions, behavior, or knowledge. The researcher collected both primary and secondary data. This involved administration of questionnaire both open and closed -ended. The selection of these tools was guided by the nature of the data collected, the time available as well as the objectives of the study. These different ways of gathering information supplemented each other and hence boosted the validity and dependability of the data. This triangulation of data is what heightened the dependability and trustworthiness of the data. The primary data was collected from the field and this gave first-hand information on agricultural infrastructure and its implication on sustainability of small holder mango farming while the secondary information was collected through document analysis which was a review of the relevant literature. This aspect considered the views and opinions of various researchers, authors and scholars on the subject.

3.8.2.2 Key informants' interview

Key informants interview was essential in generating qualitative data. This study employed Key informant interviews to collect data on critical issues relating to the specific objectives. This method utilized semi-structured interviews to guide the interview process. It involved face to face interviews with government officials and representatives from non-state actors who offer extension services in the county. The targeted key informants included County crop manager, County Agricultural officer, Cheptebo farm manager, Tot factor manager, KVDA agricultural representative, 3 wards agricultural officer and 2 transporters.

3.8.2.3 Direct Observation Method

Direct observation is an important technique to collect data when the information is considered sensitive and when a high degree of reliability and accuracy is essential. It involves researcher's presence within the geographical region where the study is carried out. The direct observation was done throughout the period of field survey with information documented. The researcher spent a significant amount of time to observe household interaction with the market , as well as the mango produce in the farms, the distributors, buyers, types of technologies used in processing mangoes, physical infrastructures available like road networks and resource based infrastructure in the study area. In this study direct observation was utilized together with a checklist in order to achieve authenticity, validation and cross-checking of the collected data on agricultural infrastructure, current livelihood status, distribution of mangoes, nature of stakeholders involvement and constraints to agricultural infrastructure activities within the household of small holder mango farmers. The researcher developed specific items to be observed and this gave the researcher an opportunity to observe the actual situation in mango farming areas. During household visits in the three Wards, the researcher observed the type of mangoes planted the Water furrows, Mango Harvesting and packaging processes, mango factories, and the road networks in the study areas. Observation method was used throughout the data collection process in order to verify information collected using other methods.

3.8.2.4 Focus Group Discussion (FGD)

This method was used to collect in -depth data from three groups of small holder mango farmers. Three FGD with farmers was conducted in Soy North Ward and Endo ward and Arror ward in Elgeyo Marakwet county. The focus group discussion provided an

opportunity for the researcher and the members of the community to explore and understand the diversity of agricultural infrastructure and its implications on small holder mango farmers. The researcher selected community members from each ward, with men, women and youths in equal ratio forming the focus group so as to provide in depth understanding of the agricultural infrastructure and its implication on small holder mango farming. A total of 3 FGDs were conducted with one session conducted in each ward, each group comprised of ten representative participants. The members of the FGDs included small holder mango farmers, inclusive of men, women and youths. Gathering information from FGD was useful in comparing different expectation, attitudes and priorities. The views of the representatives provided relevant information needed to capture the development gaps and provide entry points for intervention. The generated data was used to supplement and substantiate the quantitative data.

3.8.2.5 Documents Review

According to Blaxter, Hughes & Malcolm (2001), documents help a researcher confirm, modify or contradict his/her findings, enable a researcher to focus attention on analysis and interpretation and compliment data where they do not constitute primary data themselves. Yin (2009) argues that documents help researchers reconstruct past events as well as ongoing processes that are often relatively accurate and that documents reflect a certain kind of rationality at work. Taylor (2002) and Creswell (2009), identify common documentary sources for research as public documents like government surveys, legislation, historical records, print media content and private documents such as journals, diaries or letters. Documents written objectively on agricultural infrastructure, small holder mango farming, and sustainability and livelihood strategies were reviewed and analyzed. Secondary data was obtained through the review of relevant information from

journals, reports, websites and books. The information was relevant in the identification of the knowledge gaps and was used to supplement data that was collected through the questionnaires, key informant interviews and the focus group discussions respectively.

3.9 Validity and Reliability of Instrument

3.9.1 Validity of the instrument

In this study, content validity was established; which refers to the degree to which an instrument measures the subject matter and behaviors the researcher wishes to measure (Oso and Onen, 2008). To establish content validity, the expert judgment method was used; this is where raters/experts review all of the questionnaire items for readability, clarity and comprehensiveness and come to some level of agreement as to which items should be included in the final questionnaire (Sangoseni, Hellman & Hill, 2013). The instruments, both questionnaire and interview guide/schedule, were given to two experts who have undertaken studies in agricultural infrastructure.

The other types of validity assessed in the questionnaire were face and construct validity. Face validity is achieved when others agree that it looks like it does measure or manipulate the construct of interest (Sangoseni, Hellman, and Hill, 2013). The experts looked at the items in the questionnaire and agreed that the test was a valid measure of the concept which was being measured just on the face of it. Construct validity is the extent to which it really measures (or manipulates) what it claims to measure (or manipulate) (Sangoseni, Hellman, and Hill, 2013).

3.9. 2 Reliability of Research Instruments

To achieve reliability of a questionnaire, pilot testing was done. The pilot test sought to answer the question; does the questionnaire consistently measure whatever it measures?

According to Dikko, (2016) a pilot test of questions helps to identify unclear or ambiguous statements in the research protocol while Van Wijk and Harrison (2013) believe that pilot studies can add value and credibility to the entire research. In essence, a pilot study helps to ascertain how well a research instrument will work in the actual study by identifying potential problems and areas that may require adjustments. In this research, a pilot study was done in order to test reliability of the research instrument hence, the developed questionnaire was given to 25 respondents in Baringo County.

Baringo County was chosen because it has the same geopolitical characteristics as the county under study. The same questionnaire was administered to the same group of respondents after a period of two weeks. Data collected from pilot test were analyzed using SPSS (Statistical Package for Social Sciences); coefficient of Pearson's product moment for the test-retest was computed in order to establish the extent to which the contents of the questionnaire are consistent in eliciting the same responses every time the instrument is administered.

3.10 Methods of Data Analysis, Interpretation and Presentation

The data was analyzed using descriptive statistics (frequencies, percentages, mean and standard deviation). The mean, which indicates the average performance of a group on some measure of a variable, and the standard deviation, which indicates how spread out a set of scores is around the mean, that is, whether the scores are relatively homogeneous or heterogeneous around the mean and inferential statistics utilized. The analysis of the qualitative data (words or text or images) followed the path of aggregating the words or images into categories of information and presenting the diversity of ideas to be gathered during data collection. Data was presented using frequency tables, pie charts and paragraphs.

3.10.1 Principal Component Analysis (PCA)

Principal-component analysis (PCA) proposed by Hotelling (1933) is a procedure for reducing dimensionality (number of variables) of the datasets by representing it with a few orthogonal (uncorrelated) variables that capture most of its variability. It minimizes the loss of information and identifies new variables with greater meaning. Pricipal Component Analysis reduces data by geometrically projecting them onto lower dimensions, called principal components (Lever *et al.,* 2017). Principal components analysis attempts to model the total variance of the original data set via the uncorrelated principal components. The principal components selection process has the effect of maximizing the correlation between data and their projection. Thus, the data size can be reduced by eliminating the weaker components, that is, those with low variance (Joliffe, 2002). The main uses of PCA are descriptive, rather than inferential.

In this study Principal Component Analysis (PCA) was used to eliminate those items that had a low variance to sustain items that captured most of the variability among the services being provided. The 17 items on dynamics in the use of agricultural infrastructure by small holder mango farmers were administered to the 354 respondents. Respondents rated the extent to which they agreed with these challenges. Responses were on a Likert-type scale, ranging from 1 = “Strongly Disagree”, 2 = “Somewhat Disagree”, 3 = “Neutral”, 4 = “Somewhat Agree”, 5 = “Strongly Agree”. The study adopted this method in order to have smaller data sets that are easier to explore and visualize and make analysis of data much easier and gives a simplified interpretation.

3.10.2 Partial Least Squares Structural Equation Modelling.

Partial Least Squares Structural Equation Modelling (PLS-SEM) estimates partial model structures by combining principal components analysis with ordinary least

squares regressions (Mateos-Aparicio, 2011). PLS-SEM is referred to as variance-based, as it accounts for the total variance and uses the total variance to estimate parameters (Hair *et al.*, 2017). This study adopted PLS based structural equation modelling for the data analysis. Hair *et al*., (2014) opines that this method is useful for causal-predictive analysis and does not involve assumptions of homogeneity in variances and covariance of the dependent variable. It also can simultaneously test the structural and the measurement models, providing a complete analysis for the interrelationships. The model was appropriate because it makes minimal demands on the data distributions, sample size, and measurement scales (Hair *et al.*, 2014).

The study sought to establish the existing relationship between key latent variables that affect agricultural infrastructure using the partial least square structural equation (PLS-SEM) modeling method. The path model's analysis consists of the structural model and the measurement models.

Confirmatory tetrad analysis was conducted to ascertain the correct measurement model specification. Confirmatory tetrad analysis allows distinguishing between formative and reflective measurement models (Gudergan, *et al.*, 2008). Additionally, a bootstrapping method was used to determine the significance levels of the loadings, and path coefficients (Gholami, Sulaiman, & Ramayah, 2013).While developing the path model, the sequence of the constructs and the relationships between them were observed to ensure that they represent the hypotheses and their relationship to the theory being tested.

Exogenous latent variables only have arrows that point out of them and never have arrows pointing into them. Constructs considered dependent in a structural model (i.e.,

those that have an arrow pointing into them) often are called endogenous latent variables and are on the right side of the structural model.

3.10.3 Hierarchical Regression Analysis

The study adopted a hierarchical regression analysis to examine the contribution of agriculture infrastructure on agricultural sustainability for the various constructs under study. A Hierarchical regression is a statistical method of exploring the relationships among, and testing hypotheses about, a dependent variable and several independent variables. This method was appropriate because the study had very large number of potential predictor variables that required a determination of which variable had the most predictive power. It allowed the researcher to examine the contribution of each set of independent variables above and beyond the first group of independent variables.

3.11 Ethical Considerations

Ethical considerations in research are critical. Ethics are the norms or standards for conduct that distinguish between right and wrong. They help to determine the difference between acceptable and unacceptable behaviors. Ethical considerations are important in research because ethical standards prevent the fabrication or falsifying of data and therefore, promote the pursuit of knowledge and truth which is the primary goal of research. It is also critical for collaborative work because it encourages an environment of trust, accountability, and mutual respect among researchers. Researchers must also adhere to ethical standards in order for the public to support and believe in the research. Because ethical considerations are so important in research, many professional associations and agencies have adopted codes and policies that outline ethical behavior and guide researchers. These codes address issues such as honesty, objectivity, respect for intellectual property, social responsibility,

confidentiality, non-discrimination and many others. These codes and policies provide basic guidelines.

The study was undertaken bearing in mind all the ethical concerns and attempts to uphold them. Permission to carry out research was sought from relevant authorities like obtaining a clearance letter from Moi University authorizing the researcher to proceed for fieldwork, research permit from National Commission for Science Technology and Innovation (NACOSTI) for permission to participate in fieldwork activity; the respondents were assured of their rights, anonymity and confidentiality. They were reminded not to write their names on the questionnaire and each respondent was treated in isolation to guard against any influence.

3.12 Chapter Summary

This chapter presented the process involved in carrying out a study on agricultural infrastructure on sustainability of smallholder mango farmers Elgeyo Marakwet County, Kenya. The key areas discussed included the study area, research philosophy, research design, research approach, target population, sample procedure and sample size, data collection instruments, validity and reliability of data instruments, methods of data analysis and presentation and ethical consideration of the study. This chapter sought to justify the relevance and validity of the processes that guided and supported the study.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Overview

This chapter entails data presentation, analysis, and interpretations based on the research objectives. The main objective of this study was to examine agricultural infrastructure and its implication on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya. The specific research objectives that provided the field study framework were to;

i. Examine the agricultural infrastructure strategies adopted to enhance sustainability of smallholding mango farming.
ii. Evaluate the stakeholder involvement in agricultural support for small holder mango farming.
iii. Assess the effects of agricultural infrastructure on sustainability of smallholding mango farming.
iv. Determine the challenges on the use of agricultural infrastructure on sustainability of Smallholding mango farming.

4.2 The Response Rate

Generally, in research, the response rate is a significant concern because it ensures the questionnaires collected are valid for data analysis and the results are representative of the target population (Hair *et al.,* 2010). A total number of 370 questionnaires were distributed to small holder mango farmers in Elgeyo Marakwet County. Three hundred and sixty two (362) questionnaires out of 370 distributed were retrieved. Further, out of

the 362 collected questionnaires, only 354 were found to be useful for further analysis. Eight questionnaires were excluded from the analysis due to incompleteness, large missing data and problems of outliers as explained in table 4.1. The remaining questionnaires accounted for 96.1 % of valid response rate.

Table 4. 1: Response Rate

No	Response	Frequency	Percent (%)
1.	No. of distributed questionnaires	370	100 %
2.	Complete and returned	362	98.3 %
3.	Unusable questionnaires	8	2.17 %
	• Incomplete and ineligibility	5	1.63 %
	• Univariate and a multivariate	3	0.54 %
4.	**Returned and usable questionnaires**	**354**	96.1 %

Source: Field Survey, 2021

4.3 Preliminary Analyses Tests

4.3.1 Data Coding and Screening

In this study, the survey data was screened for a number of potential problems in relation to missing data according to guidelines provided by Tabachnick and Fidell (2013). The returned questionnaires (362) were keyed into SPSS v24 variable view page. Each item/question was coded and given a name based on its main variable initials and under the same latent construct.

4.3.2 Missing Values Analysis

According to Hayes (2012), missing values are a common occurrence in social research. This explains why it is statistically important to check for missing values before conducting any analysis. Furthermore, Dong and Peng, (2013) and Garson, (2015)

argue that overlooking cases with missing values could lead to the loss of vital information, which subsequently minimizes the statistical power and increases standard errors. In addition, according to Hair *et al*., (2010) the indication of a missing data is when a respondent failed to deliver an answer concerning one or more questions thus making the data collected not appropriate for subsequent analysis. In view of the effect of missing values, steps were undertaken by the researcher to prevent the problem of missing data right from the field of data collection in an effort to decrease their rate. Each questionnaire was thoroughly checked upon receipt to make sure that all questions were properly answered. The variables with missing values were ignored and retained since they had missing values of 5 % or fewer of the cases as suggested by Tabachnick and Fidell, (2013).

4.3.3 Analysis of Outliers

Data screening in social research involves the treatment and assessment of outliers. Outliers are extreme scores or values of data sets that may significantly affect the analysis and the result of the study (Hair *et al.*, 2010). Two types of outliers namely univariate and multivariate were assessed in this study. The presences of univariate outliers can be detected using either standardized variable values (Z score) or by using frequency distribution tables such as histograms, box plots, and normal probability plots. The study uses standardized variable values (z-scores) threshold of more than 3.0 and less than -3.0 being considered outliers by Tabachnick and Fidel (2013). Thus, a total of 3 cases were identified using standardized values as potential univariate outliers. The univariate outliers were deleted from the dataset because they would have affected the accuracy of the data analysis technique.

4.4 Demographic Profile of Respondents

Demographic profile of the respondents provided significant information in articulating the set objectives. The section focuses on the demographic profile of the study participants. In line with this, the gender, age, educational levels, marital status, household size, size of land under mango production, years engaged in mango production, how the mango farm was obtained, motivation for growing mangoes, major economic activity and range of income of the participants were analyzed. Demographic profile analysis informed the study in terms of how gender, age, education and size of land under mango production influenced the adoption of agricultural infrastructure, stakeholder's involvement and use of agricultural infrastructure.

4.4.1 Gender of the Household Heads

The study considered gender of participants and their role in adopting agricultural sustainability strategies. According to Peterman *et al.* (2014), the success in agricultural development is greatly influenced by differences in roles between men and women and which, therefore, should be considered.

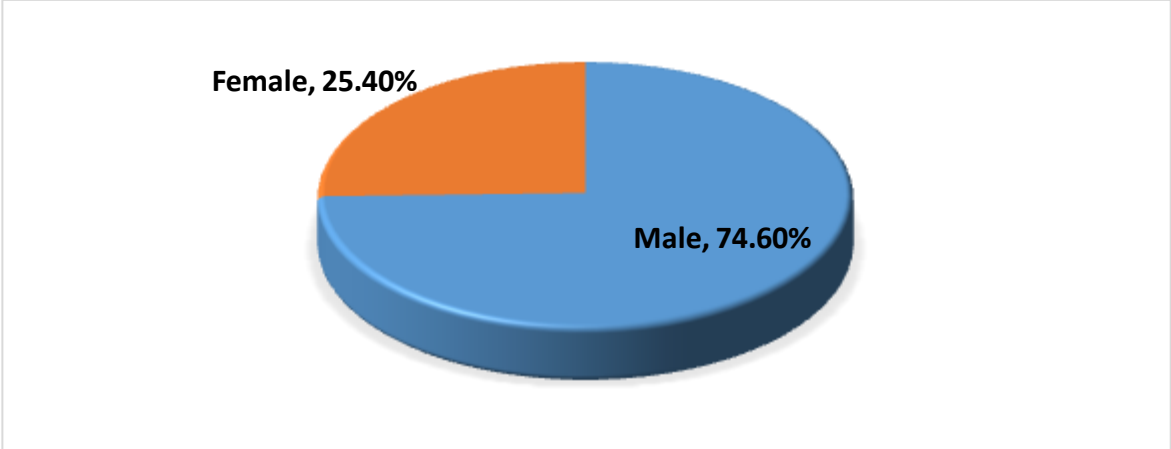


Figure 4. 1: Gender of the Small Holder Mango Farmers

Source: Field Survey, 2021

The survey data as indicated in Figure 4.1 shows that, majority of mango farmers respondents were men as compared to women. This further implies that the responses in the research represented both genders. One of the possible explanations why few women in Elgeyo Marakwet engage in mango farming could be social and cultural factors and the fact that mango farming is dominated by men (74.6 %). ABD (2011) attributes the low number of women in mango farming to the prevailing socio cultural factors where land and permanent crops are generally owned by men.

The study conducted a crosstab analysis to establish the role of gender on agriculture infrastructure. The constructs analyzed included; size of mango land, nature of acquisition of land, primary source of farmer occupation, income of farmers, additional farm training skills, technologies adopted, financing of farming activities and lastly barriers to credit access. This was informed by the fact that the success in agricultural development is greatly influenced by differences in roles between men and women (Peterman *et al.* (2014). Additionally, very few women are considered to be the ultimate owners of mango trees or the land upon which the mango is planted, and husbands mostly have exclusive interaction with mango traders and complete control over the allocation of the mango proceeds (Rockefeller Foundation, 2018).

Table 4. 2: Correlation between Gender and Agriculture Infrastructure

Variable Constructs	Pearson Chi-Square		
	Value	**Df**	**Asymptotic Significance (2-sided)**
Gender * Size of land under Mango Production	32.874[a]	23	0.083
Gender * How was your mango farm acquired	1.947[a]	3	0.583
Gender * Is Mango production your primary or secondary occupation	.014[a]	2	0.993
Gender * Range of income from mango farming	6.125[a]	4	0.190
Gender * Training on value addition technologies	.817[a]	1	0.366
Gender * How did you finance mango related operations in the last season	5.535[a]	5	0.354
Gender * Indicate barriers to access credit	**3.735[a]**	**3**	0.291

Source: Field Survey, 2021

The Pearson chi-square values for the various variable constructs indicated that gender did not play a significant determinant for ownership and access for the various agriculture infrastructures. In particular, gender did not determine the ownership and size of land under mango production χ^2 (354, 23) = 32.874, p = 0.083). This implies that women were not disproportionately disadvantaged due to ownership by size of land under mango production. These results indicate a clear contrast of the findings by FAO, (2011) and Farnworth *et al.*, (2016) who argue that women's unequal access to key agricultural inputs such as land, labour, knowledge, fertilizer, and improved seeds and seedlings contributes to the persistence of the gender gap yet women and girls make almost half of the agricultural workforce in developing countries.

The study sought to establish whether gender played a significant determinant in acquiring land through outright purchase, rented land, family land and community land. The study findings indicate that gender was not a significant determinant of the nature

of land acquisition for mango farming (χ^2 (354, 3) = 1.947, p = 0.583). This results however contradict with Perez *et al*., (2015), Quisumbing & Pandolfelli, (2010) who found out that, women's activities in agriculture are characterized by a global gender gap in vulnerabilities, access to resources, and productivity.

On whether gender was a significant determinant on whether mango production was a primary or secondary occupation, the findings indicate that gender was not a determinant (χ^2 (354, 2) = 0.014, p = 0.993). The results contrast with those of Okorley *et al*. (2014) who found out that crop production in Ghana is dominated by men, the reason being that a plantation crop such as mango requires a large span of farmland, high initial capital, and labour which Ghanaian women generally lack. However, there is a high women presence in the distribution and marketing of the mango fruits locally. More importantly, according to MoFA, (2011), mango production in Ghana is generally considered a male activity, even though women play major roles in the post-harvest practices and other farm management activities like weed control.

The study sought to establish the relationship between gender and training on value addition technologies. The study established that gender is not a determinant on training on value addition (χ^2 (354, 1) = 0.817, p = 0.366). According to Team and Doss, (2011), the reduced role of women arises from gender inequalities in engaging in agriculture and in adoption of new technologies, often attributed to women lacking access to land, education, extension services, training programs and financial services.

The study also sought to establish whether gender played a significant determinant on income from mango farming. The results indicate that gender was not a significant determinant on the income received from mango farming (χ^2 (354, 4) = 6.125, p = 0.190). The results of Okorley *et al.* (2014) found out that crop production in Ghana

such as mango requires a large span of farmland, high initial capital, and labour which generally affects the income obtained from the mango production.

The findings on whether gender determines how farmers finance mango related operations indicated that gender was not a determinant. χ^2 (354, 5) = 5.535, p = 0.354). According to Sheahan and Barrett (2014) and World Bank (2012), substantial gender gaps in access and control continue to exist in regard to six key resources and inputs for agriculture: land, labor, credit, information, extension, and technology.

4.4.2 Age of the Respondents

The age of the respondents plays a significant role in engagement in sustainable small mango farming. Assessing the role of age in adoption of agricultural infrastructure is a key in achieving sustainability.

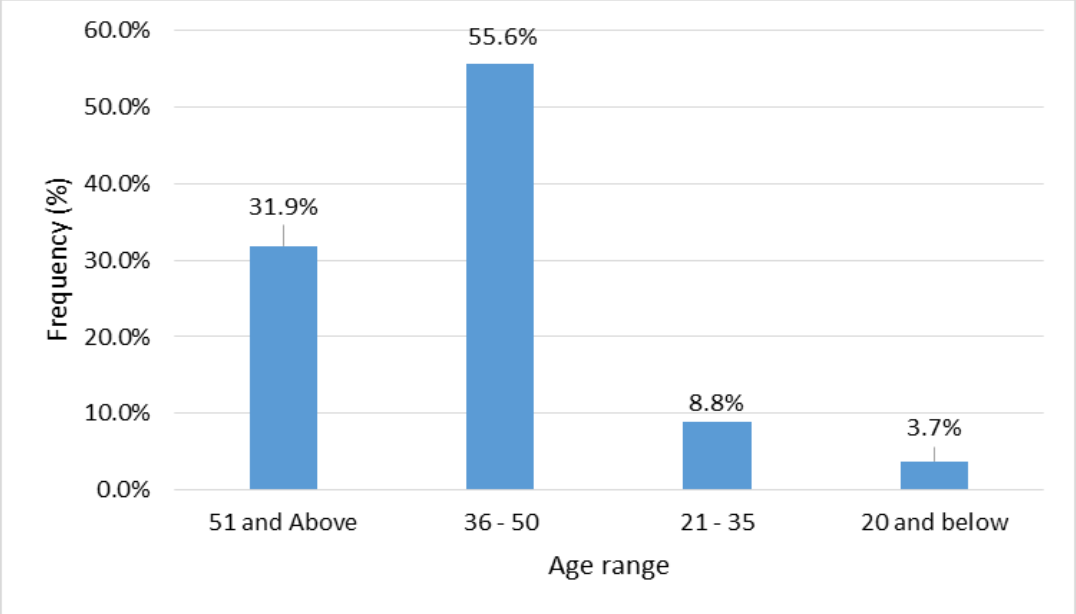


Figure 4.2: Ages of the Participants

Source: Field Survey, 2021

The 36 - 50 age group categories had a high frequency. This implies that it is mostly the youthful and productive segment of the population that engages in mango farming. This

can further imply that they can easily adopt technological practices. The results contradict with those of Ahmed *et al* (2017) who found out that persons aged between 25 years to 50 years, are interested in mango production in Bangladesh. It is in agreement with those of Eghan (2017) and Okorley (2014) who found that mango farming in Southern Ghana is dominated by the elderly. Naamwintome & Bagson, (2013) argues that youth engagement in agriculture has been found to increase agricultural productivity considering that this group are in their physical and mental primes of their lives, are flexible and dynamic, and are relatively more educated than the elderly population. Literacy means farmers have the ability to get, understand and use agricultural information education exposure also enables farmers to store and later use that information (Opara, 2012; Rehman *et al.*, 2013). While most of the world's food is produced by (ageing) smallholder farmers in developing countries, older farmers are less likely to adopt the new technologies needed to sustainably increase agricultural productivity, and ultimately feed the growing world population while protecting the environment (FAO, 2017).

The study conducted a crosstab analysis to establish the role of age on agriculture infrastructure. The constructs analyzed included; size of mango land, nature of acquisition of land, primary source of farmer occupation, income of farmers, training on value addition technologies, financing of farming activities and lastly barriers to credit access. This was informed by the fact that age plays a significant role in engagement in sustainable agriculture practices.

Table 4. 3: Correlation between Age and Agriculture Infrastructure

Variable Constructs	Pearson Chi-Square		
	Value	df	Asymptotic Significance (2-sided)
Age *Size of Land under mango production	127.849[a]	69	0.000
Age * How was your mango farm acquired	17.940[a]	9	0.036
Age* is Mango production your primary or secondary occupation	4.653[a]	6	0.589
Age * Range of income from mango farming	26.414[a]	12	0.009
Age* Training on value addition technologies	14.083[a]	3	0.003
Age * How did you finance mango related operations in the last season	48.540[a]	15	0.000
Age * Indicate barriers to access credit	12.905[a]	9	0.167

Source: Field Survey, 2021

The Pearson chi-square values for the various variable constructs indicated that age was a significant determinant for ownership and access for the various agriculture infrastructures. In particular, age determined the ownership and size of land under mango production χ^2 (354, 69) = 127.849, p = 0.000). The results concur with those of Ahmed *et al* (2017) who found out that middle-aged people between 25 years to 50 peoples are interested in mango production in Bangladesh. It contradicts findings by Eghan (2017) and Okorley (2014) who found that mango farming in Southern Ghana is dominated by the elderly.

The study sought to establish whether age played a significant role in acquiring land through outright purchase, rented land, family land and community land. The study findings indicate that age was a significant determinant of the nature of land acquisition for mango farming (χ^2 (354, 9) = 17.940, p = 0.036). The focus group discussion

revealed that the majority, especially the young farmers, were farming on the family land since majority cannot afford to purchase their own land due to financial constraints. Land transfer gives farmers qualified collateral, so more lands should give farmers more probability to apply for more credit, but farmers with more lands would not like to apply for more credit, because of the risk of losing lands (Reyes and Lensink, 2011).

On whether age was a significant determinant on whether mango production primary or secondary occupation, the findings indicate that age was not a determinant (χ^2 (354, 6) = 4.653, p = 0.589). On the contrary, a key informant revealed that most of the youths tend to prefer being employed instead of taking mango farming as their primary occupation. According to Youth in Farming (2011), Young people perceive agriculture as a profession of intense labour, not profitable and unable to support their livelihood compared to white collar jobs offer. They think agriculture would not afford them to enjoy the pleasures of owning a beautiful home, fast cars, the latest gadgets and mobile phones like what their colleagues in white collar jobs have access to. When one talks about agriculture or farming, in the minds of young people, they think of someone far down in a village living in a shack, who wakes up very early every morning to go dig coming back home at sunset. This farmer in their minds, is so far away detached from civilization, wears barely any clothes and is the typical person who lives on less than a dollar a week. African agriculture or farming is mostly of hoe and machete which makes it very energy and labour intensive. This is the most common example of farmers that almost every young person knows. From an early stage, every young person detests and tries to avoid this sort of life. *As a child, if any of us did not want to go to school, our parents would intimidate us with words like "ok, you are going to end like a farmer, living a very hard life and getting infected with lice and no one is going*

to want to be near you". In Africa, parents always encourage their children to study to become doctors, accountants, in other-words professionals in white collar jobs. From the onset, farming or a career in agriculture is frowned upon as a poor man's business. There is also the possibility that banks chosen by the government to administer agricultural loans often connive with politicians and put all sorts of impossible obstacles on the paths of these youths in order to frustrate them from getting the loans. Banks want quick returns on the loans meant for agricultural projects that they have to give out to youth in farming, but instead they lend out the money out to non-agriculture sectors that would bring in quicker and more lucrative returns. This often means many applications for these agricultural loans especially from young farmers are unfortunately rejected (Youth in Farming, 2011).

The results indicate that age was a significant determinant on the income received from mango farming (χ^2 (354, 12) = 26.414, p = 0.009).This implies that the age category that engages more in mango farming received a higher income from mango farming.

The study sought to establish the relationship between age and training on value addition technologies. The study established that age is a determinant on training on value addition (χ^2 (354, 3) = 14.083, p = 0.003). According to Genius *et al* (2014), younger farmers prevail among the early adopters of sustainability as compared to older farmers who act as late adopters since younger farmers seem to be more prone to implement soil and water conservation practices, particularly in recent years. Grammatikopoulou *et al* (2015) demonstrate that being an early adopter of organic farming practices and frequent contact with young and highly educated farmers increases the probability of adoption of other agri-environmental measures by organic

farmers in Germany. In addition, (Manda *et al*. 2016), opine that young farmers may be more flexible in adopting new technologies than their older counterparts.

The findings on whether age determines how farmers finance mango related operations, they indicated that age was a determinant. χ^2 (354, 15) = 48.580, p = 0.000).The FGD revealed that the young farmers who lacked identification cards and were not members of farmers groups did not access any financial support from the groups.

Lastly, the study sought to establish whether age was a significant factor on barriers in credit access. The results indicate that age was not a determinant to credit access χ^2 (354, 9) = 12.905, p = 0.167). This indicates that any farmer could access credit as long as they meet all the minimum requirements as stipulated by the credit agencies.

4.4.3 Education Level of the Participants

Education level provides insight into the farmer's knowledge in the adoption of agricultural sustainability practices. Education can be a means of improving people's welfare since it provides individuals with the capacity to obtain a higher income and standard of living. It is widely documented that education is key to overcoming development challenges in rural areas. Not only is there a direct link between food security and education but it has also been shown that basic numeracy and literacy skills help to improve farmers' livelihoods (FAO, 2007). As the level of education of smallholder farmers with access to infrastructure increases, the agricultural income of the farmers also increased. This is due to the fact that educated farmers easily adapt to innovation and understand the fundamentals of production easier, thus implying that educated farmers were able to better utilize infrastructure that is made available to them. With better utilization of infrastructure, farmers in the study are able to increase their agricultural income.

Literacy means farmers have the ability to understand and use agricultural information (Opara, 2012; Rehman *et al*., 2013). Education exposure also enables farmers to store and later use that information.

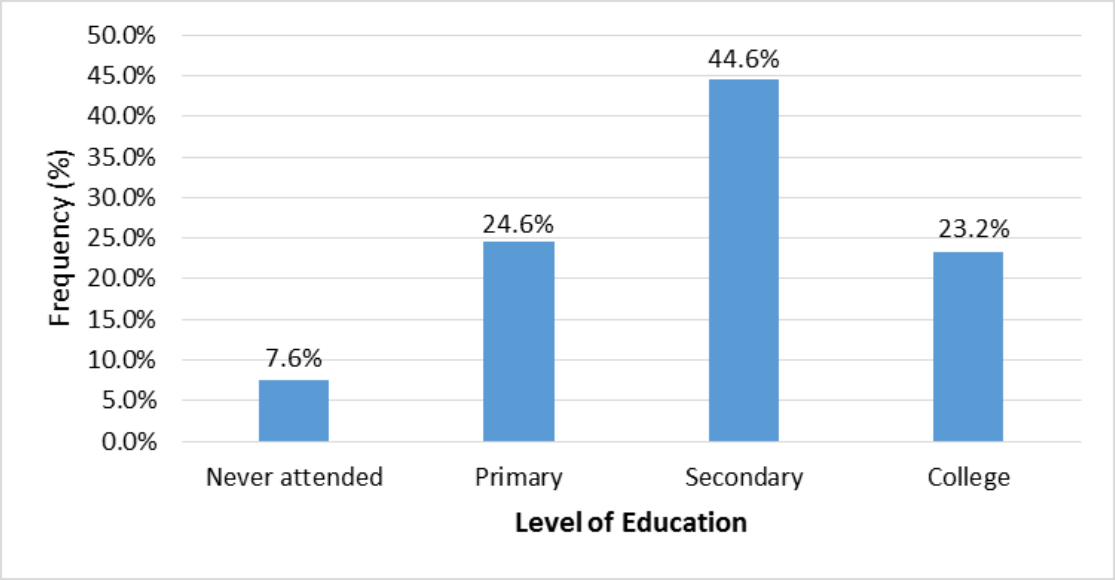


Figure 4. 3: Education Level

Source: Field Survey, 2021

The study revealed that the majority of the small holder mango farmers were literate since they had attained secondary education and this could assist them to be more enlightened in adopting innovations than illiterates. One of the possible explanations why the majority engages in mango farming is that, many with secondary education and below has limited employment opportunities in the formal sectors. Additionally, the Focus Group Discussion (FGD) revealed that the majority of the youth do not proceed to secondary or to college due to several reasons such as; low income, poverty, unemployment, low grades, and peer pressure which contributes to education apathy.

The educational levels of respondents is vital in production and marketing decisions making process, as reported by Nzomoi *et al* (2017) and indicate that highly educated farmers and marketers are better adopters of improved technologies than less educated

ones. In a similar study, Oduro-Ofori *et al*, (2014) indicated that a formal secondary education level was adequate for famers to comprehend technology used in agriculture, and extension education had more returns to agricultural productivity in Ghana. This result acknowledges the importance of education for the conception of the principles of basic production. According to Ferreira (2015) educated farmers are more likely to adopt new technologies, and this, in turn, leads to the diffusion of technology to other less educated farmers within the community.

The study further conducted a crosstab analysis to establish the role of education on agriculture infrastructure. The constructs analyzed included; size of mango land, nature of acquisition of land, primary source of farmer occupation, income of farmers, training on value additional technologies, , financing of farming activities, barriers to credit access, age and motivation for growing mangoes. This was informed by the fact that education plays a key role in use of agricultural strategies.

Table 4. 4: Correlation between Education and Agriculture Infrastructure

Variable Constructs	**Pearson Chi-Square**		
	Value	Df	Asymptotic Significance (2-sided)
Education * Size of Land under mango production	100.216[a]	69	0.008
Education * How was your mango farm acquired	22.177[a]	9	0.008
Education* is Mango production your primary or secondary occupation	8.766[a]	6	0.187
Education * Range of income from mango farming	30.998[a]	12	0.002
Education * Training on value addition technologies	12.256[a]	3	0.007
Education* How did you finance mango related operations in the last season	20.230[a]	15	0.163
Education * Indicate barriers to access credit	16.301[a]	9	0.061
Education * Age of respondents	29.867[a]	9	0.000
Education * What is your motivation for growing mango?	19.359[a]	12	0.080

Source: Field Survey, 2021

The Pearson chi-square values for the various variable constructs indicated that education was a significant determinant for ownership and access for the various agriculture infrastructures. In particular, education determined the ownership and size of land under mango production χ^2 (354, 69) = 100.216, p = 0.008). According to Mujuka *et al* (2020) the indication of relatively high level of literacy of the farmers can imply higher cognitive ability, access to information and are more likely to adopt technologies that have potential for higher economic gains. The results concur with Okorley *et al*. (2014) who found out that the youth engage in mango farming after completion of senior secondary school education.

The study sought to establish whether education played a significant determinant in acquiring land through outright purchase, rented land, family land and community land. The study findings indicate that education was a significant determinant of the nature of land acquisition for mango farming (χ^2 (354, 9) = 22.177, p = 0.008). This further indicates that those who had attained higher levels of education and were employed had used their income to purchase land for mango farming.

On whether education was a significant determinant on whether mango production primary or secondary occupation, the findings indicate that education was not a determinant (χ^2 (354, 6) = 8.766, p = 0.187). The FGD revealed that some farmers had attained a high level of education but due to unemployment they resorted to mango farming.

The study sought to establish the relationship between education and training on value addition technologies. The study established that education is not a determinant on training on value addition (χ^2 (354, 3) = 12.256, p = 0.007). This result, however, is in tandem with the assertions of Jibowo (2000) and Brunello (2004) that education and

training improves the skill, attitude and knowledge of an individual thus sharpening their ability to comprehend and apply innovations with ease. Therefore, since the majority of the respondents were educated, it is expected that they would adopt and utilize more agricultural technologies than those who had no formal education.

The study also sought to establish whether education played a significant determinant on income from mango farming. The results indicate that gender was a significant determinant on the income received from mango farming (χ^2 (354, 12) = 30.998, p = 0.002). This implies that an educated farmer is it is expected to adopt and utilise agricultural technologies that increases income from mango farming.

The findings on whether education determines how farmers finance mango related operations indicated that education was not a determinant. χ^2 (354, 15) = 20,230, p = 0.163). Key informant interviews revealed that financing of mango was influenced by funding organization operations.

The study also sought to establish whether education was a significant factor on barriers in credit access. The results indicate that education was not a determinant to credit access χ^2 (354, 9) = 16.301, p = 0.161). This can be attributed to the fact that access to credit is determined by the requirements stipulated by the credit lenders.

On the relationship between education and age the results show that education was a determinant on age of mango farmers χ^2 (354, 9) = 29.867, p = 0.000). Naamwintome & Bagson, (2013) opine that youth engagement in agriculture has been found to increase agricultural productivity considering that this group are in their physical and mental primes of their lives, are flexible and dynamic, and are relatively more educated than the elderly population. He further argues that the benefits of the engagement of youth in agriculture can help achieve the Sustainable Development Goals (SDGs) 1 of no

poverty; 8 of decent work and economic growth and; 10 of reduced inequality. Nzomo *et al* (2007) reported that the educational level of farmers is vital in production and marketing decisions making process in that highly educated farmers and marketers are better adopters of improved technologies than less educated ones.

Lastly the study sought to establish whether there was a significant relationship between education and motivation for growing mangoes. The results show that education was not a determinant in motivation for growing mangoes χ^2 (354, 12) = 19.359, p = 0.080). This further indicates that both the educated and uneducated engages in mango farming. According to Mujuka *et al* (2020) the indication of relatively high level of literacy of the farmers can imply higher cognitive ability, access to information and are more likely to adopt technologies that have potential for higher economic gains. The results concur with Okorley *et al.* (2014) who found out that the youth engage in mango farming after completion of senior secondary school education.

4.3.4 Marital Status

Marital status has implications on adoption of agricultural innovations and technologies as supported by the findings of Idrisa *et al* (2014) and Mohammad, Achem, Abdulquadri (2014) who reported that married people have more responsibilities and hence enter any enterprise with higher levels of seriousness. This makes them frequently seek information about improved agricultural innovations/technologies so as to enhance the welfare of their families.

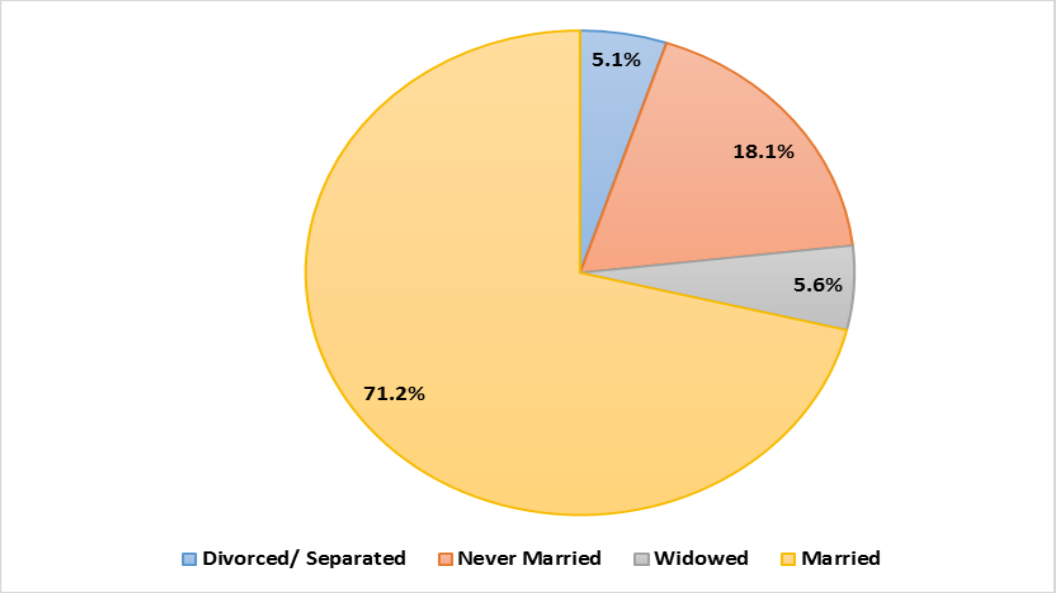


Figure 4.4: Marital Status

Source: Field Survey, 2021

The study found out that the majority of the respondents were married (71 %), 18, 1 % were not married, 5.6 % widowed, 5.1 % divorced or separated. This could be attributed to the fact that when one gets married, one's assets may increase and his or her partner could bring some income into the house. Such income could be used to procure more inputs, which could be used in the production activities of farmers, thus increasing agricultural income. Findings by Muhie, and Yimer, (2013) also found out that a greater population of those who engaged in mango production were married, an indication of the significance role played by this enterprise in the economic life of families. They posit that married people were attracted into it as a way of supporting their expanding families. An interesting thing is that mango retail marketing in the area seems to be exclusively a female affair. Ayele and Bosire, (2011) found that married farmers had more networks and access to new technologies than unmarried, divorced and widowed while Opara (2010), argues that married farmers/producers are more likely to be under pressure to produce more as well, for sale and thus necessitate agricultural information

seeking and use. Similarly, large family labour availability could motivate the farmers to grow more crops and use agricultural information.

4.4.5 Household Size

Household size increases domestic consumption requirements and renders households more risk averse. Controlling dependency ratio, larger households are expected to contribute for labor supply during harvesting and transporting mango and it would enhance market participation (Regasa *et al*, 2019).The study sought to establish the household size in the study area.

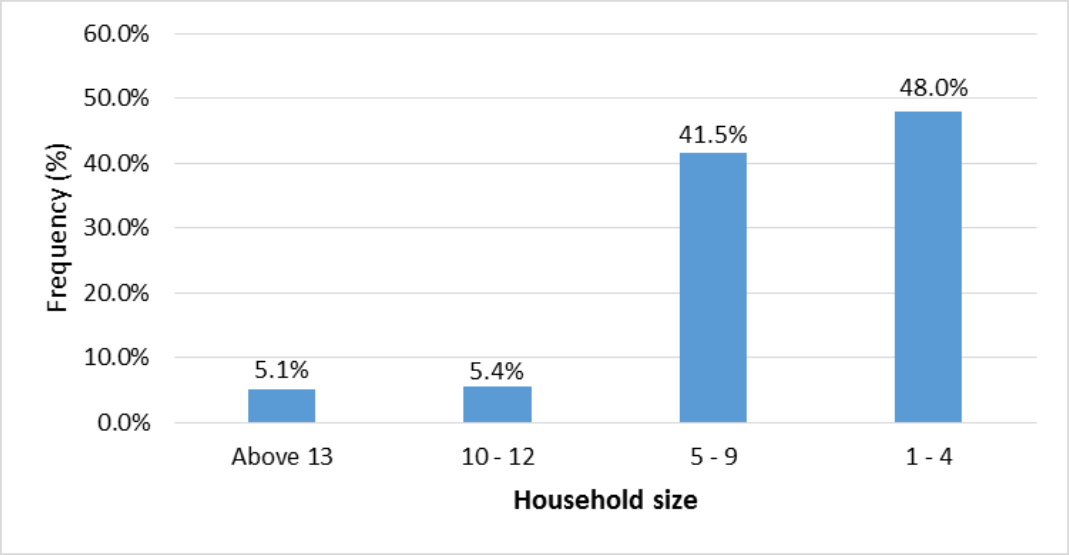


Figure 4. 5: Household Size

Source: Researcher, 2021

The findings indicate that almost half of the mango farmers consist of the household size 1 - 4 of members and 5 - 9 members. This implies that respondents need very high incomes to meet the needs of their huge dependent families. The household size determines the amount of labor available for farm production, farm produce kept for own consumption and agricultural marketable surplus of farm harvest (Amaza *et al*, 2009) Households with large family members are mostly associated with a high dependency ratio and more food requirements, depicting a negative effect on food

security. However, an increase in household size could translate into an increase in the number of income-earning adults depicting a positive effect on food security (Iyangbe and Orewa, 2009).

The study further conducted a crosstab analysis to establish the relationship between the household size and agriculture infrastructure. The constructs analyzed included; size of mango land, nature of acquisition of land, primary source of farmer occupation, income of farmers, financing of farming activities, age, motivation for growing mangoes, gender and education level. This was informed by the fact that the household size determines the amount of labor available for farm production, farm produce kept for own consumption and agricultural marketable surplus of farm harvest (Amaza *et al*, 2009).

Table 4. 5: Correlation between Household Size and agriculture infrastructure

Variable Constructs	Pearson Chi-Square		
	Value	df	Asymptotic Significance (2-sided)
Household Size * Size of land under mango farming	157.131[a]	69	0.000
Household Size* How was your mango farm acquired	37.692[a]	9	0.000
Household Size * is Mango production your primary or secondary occupation	34.194[a]	6	0.000
Household Size * What is your motivation for growing mango?	40.446[a]	12	0.000

Source: Field Survey, 2021

The Pearson chi-square values for the various variable constructs indicated that household size was a significant determinant for ownership and access for the various

agriculture infrastructures. In particular, household size determined the ownership and size of land under mango production χ^2 (354, 69) = 157.131, p = 0.000). This indicates that a household with many dependents can be forced to increase mango production in order to cater for the family.

The study sought to establish whether household size played a significant determinant in acquiring land through outright purchase, rented land, family land and community land. The study findings indicate that household size was a significant determinant of the nature of land acquisition for mango farming (χ^2 (354, 9) = 37.692, p = 0.000). The FGD also revealed that farmers from large families had gone an extra mile to purchase land for farming to enable them increase their income so as to ensure that they can adequately feed and provide for their families. On whether household size was a significant determinant on whether mango production was a primary or secondary occupation. The findings indicate that household size was not a determinant (χ^2 (354, 6) = 34.194, p = 0.000). This can be attributed to the fact that engagement in mango farming was available to all the residents since the land is fertile but decision to engage in farming was an individual household decision.

The study also sought to establish whether there was a significant relationship between household size and motivation for growing mangoes. The results show that household size was a determinant in motivation for growing mangoes χ^2 (354, 12) = 40.446, p = 0.000). This implies that a large household size provides sufficient of labor for farm production and hence acts as a motivation for growing mangoes.

4.4.6 Size of Land under Mango Production.

The study sought to establish the relationship between the size of land under mango production and the years farmers have been involved in mango production. The

research hypothesized that sustainable mango farming implies increase in acreage of mango production with increase in the years of farming.

Figure 4.6: Analysis of Variance

ANOVA					
Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	493.486	1	493.486	34.793	.000[b]
Residual	4992.613	352	14.184		
Total	**5486.100**	**353**			

Source: Field Survey, 2021

From Table 4.6, the regression equation indicated that there was a positive relationship between size of land under mango farming and years of farming. This relationship was statistically significant (F (354, 1) = 34.793 P= 0.000< 0.05. This implies that the years of production is a function of the size of land under mango production. It can therefore be concluded that the size of land under mango production increased with the years in mango farming.

4.4.7 Acquisition of Mango Farm land

Generally, farmers acquire farming land in different ways. The study sought to establish how small holder mango farmers acquired their land.

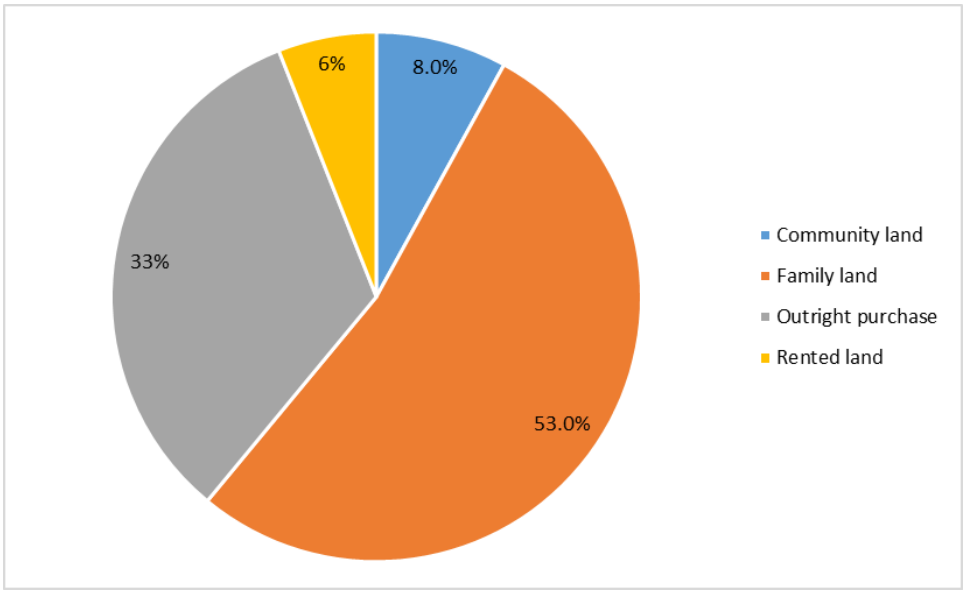


Figure 4.7: Mango Farm Land Acquisitions

Source: Field Survey, 2021

The findings indicate that 53 % were farming on the farming land, 33 % on purchased land, 8 % on community land and 6 % on rented land. This indicates that slightly half of the respondents are growing mango on family land. This implies that they are farming on land inherited from their parents. In addition, the higher percentage of outright purchase of land indicates that the farmers are increasing their farm land. Plate 4.1 show the researcher in one of the family fenced family land.

Plate 4.1: Researcher in one of the Family Fenced Family Land.

Source: Field Survey, 2021

The results concurs with studies by FAO (2014), which opines that land used to be owned by the community, lineage or clan, the control and management of land is becoming increasingly individualized. In developing countries, poverty often forces parents to sell their land to outsiders, excluding younger community members from land access. Large-scale land deals are particularly unfair towards young people, given that they are often not even consulted on agreements which may bar their and the next generations' access to land (White, 2012). In densely populated countries such as Rwanda, land has been highly fragmented and laws adopted prohibiting any further division of land. In practice, this means that the eldest son is the sole family heir and the

final decision maker (IFAD, 2010b). What is more, increasing land degradation (FAO, 2011b) further limits the arable land available for young people.

It is unrealistic to expect youth to purchase land through acquired savings, given high rates of youth unemployment, low wages for most rural youth and high land prices. For young women in developing countries it is an even greater challenge to obtain the necessary capital to buy land as they often do unremunerated household work or subsist on low wages (FAO, 2011a).

4.4.8 Mango Farming Occupation

The study sought to establish whether mango farming was a primary or secondary occupation of the small holder farmers.

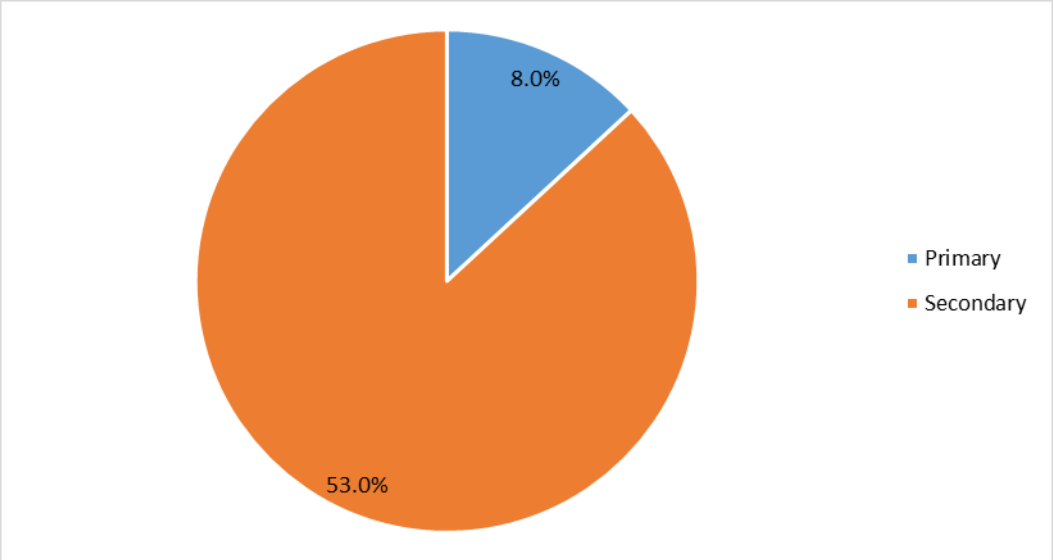


Figure 4.8: Occupation

Source: Field Survey, 2021

The results show that most of the smallholder mango farmers indicated that mango farming was their primary occupation which further implies that mango farming was their main source of livelihood. It can be attributed to the free entry to mango farming as a livelihood opportunity in the county.

4.4.9 Motivation for Growing Mangoes

The study sought to establish what motivated smallholder farmers to grow mangoes

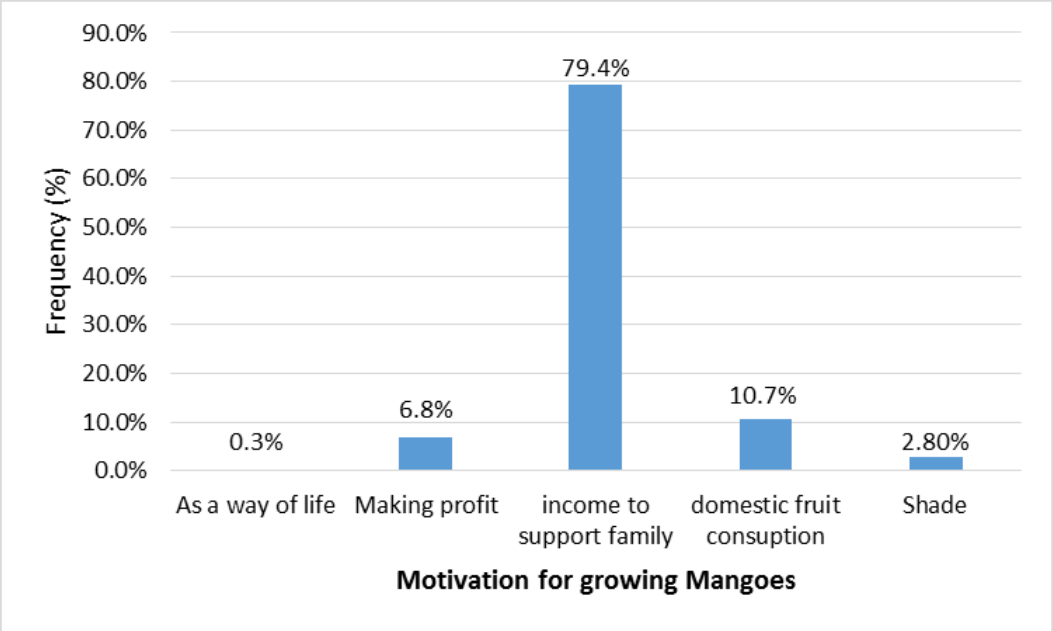


Figure 4.9: Motivation for Growing Mangoes

Source: Field Survey, 2021

The study established that 79.4 % (281) of the smallholder mango farmers were motivated to engage in farming to obtain income that will enable them to support their families**.** 10.7 % were motivated because of domestic fruit consumption, 6.8 % to make profit, 2.8 % shade and 0.03 % as a way of life. This indicates that majority of the mango farmers are in mango farming to obtain income to support their families.

4.4.10 Major Economic Activities

Small holder farmers utilize all resources available and accessible to them to derive their source of livelihoods from various economic activities to ensure their survival.

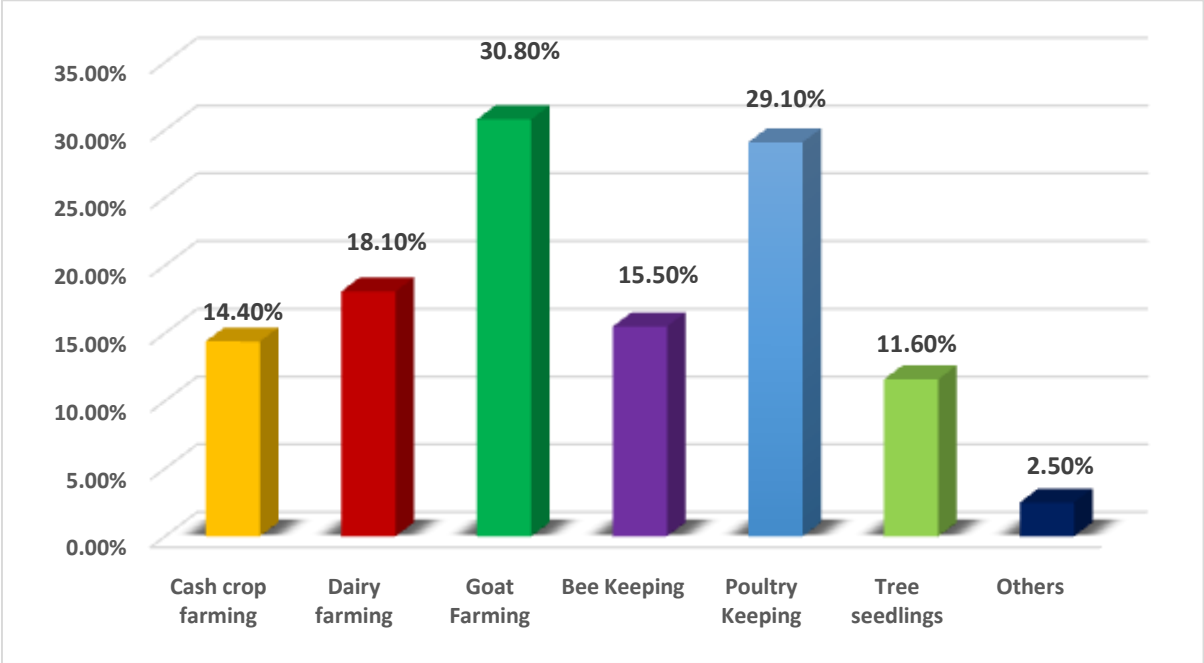


Figure 4.10: Economic Activities

Source: Researcher, 2021

The smallholder mango farmers engage in different economic activities but mainly in goat farming and poultry keeping as shown in the figure above a clear indication that they rely more on agriculture than on non-agricultural sources .The results imply that the farmers diversify their sources of income. The findings are consistent with Sisay (2010) and OECD, (2011) who showed that households seek to diversify their livelihood to help reduce risks, particularly those associated with seasonality of rain-fed agriculture.

4.4.11 Range of Income

The study sought to establish the range of income per month from mango farming. According to OECD (2013), income provides security and financial leverage affects the ability to invest in farming.

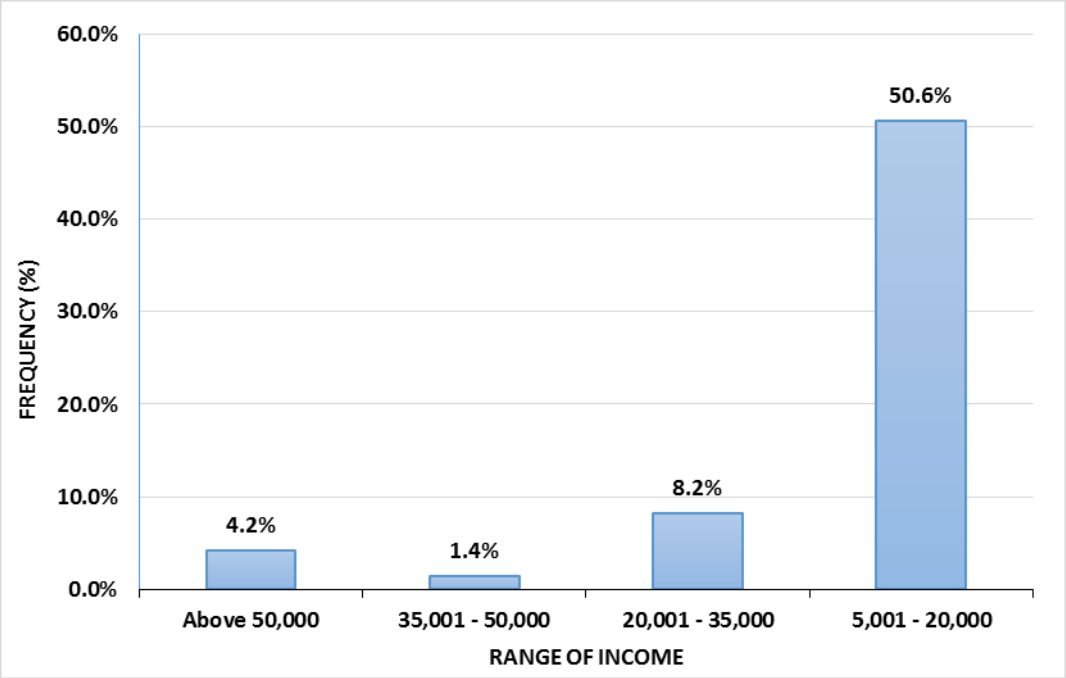


Figure 4.11: Range of Income

Source: Field, Survey, 2021

The findings indicate that the majority earn below Kshs 20,000 this implies that what they earn from mango farming cannot enable them to satisfy all their needs. The FGD further revealed that due to low income most of the smallholder mango farmers cannot meet the cost of farm inputs, transport and harvesting which cause many of them to sell their mango on the farm or rely on middlemen.

4.5 Agricultural Infrastructure

The first objective of the study was to examine the agricultural infrastructure development oriented strategies adopted to enhance the sustainability of smallholder mango farming. Sustainable agricultural infrastructure are the most promising pathways to enhance the productivity and resilience of agricultural production of smallholder farming systems while conserving the natural resources Goyol & Pathirage, (2017). According to Du, Pinga, Klein and Danton, (2015) and Patel (2014,) agricultural

infrastructure can be grouped under input based infrastructure, resource based infrastructure, physical infrastructure and institutional infrastructure.

4.5.1 Input based infrastructure

Input based infrastructures include seed, fertilizer, pesticides, farm equipment and machinery that they farmers use.

4.5.1.1 Mango Variety

Farmers in mango growing regions grow multiple varieties of mangoes. The study sought to establish the mango variety grown in the Elgeyo Marakwet.

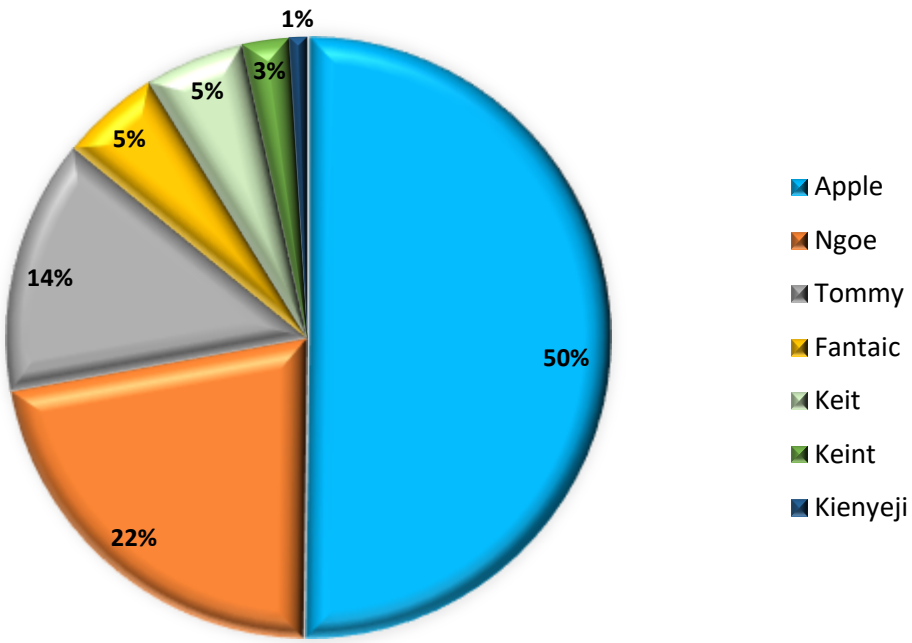


Figure 4. 12: Mango Variety

Source: Researcher, 2021

The results of the study show that farmers in the region grow multiple varieties of mangoes. The most dominant varieties grown are the apple variety (74.3%) followed by Ngoe and Tommy respectively. Interview with the farm manager at Cheptebo Processing Plant revealed that apple was the most preferred variety because it has the

highest local demand and is suitable for processing as shown in Plate 4.2 and Plate 4.3. Further, it was revealed through the FGD that farmers in Chesongoch area grow the traditional and crafted mangoes for export. The traditional names of the mangoes include: *pandakasike* which means that anyone can pick and eat them because they are readily available, *Kipkulung* these are round mangoes which looks like a red quard, tree top: these are bigger and few fruits compared to the first two and is purely for export.

The results concur with those of FSD (2015) who found out that the most dominant variety of mango grown in Eastern Kenya was Apple. They further argue that apple variety is gaining popularity for processing by industrial processors; however, it is largely used by smaller artisanal food processors who use blenders and other smaller machines and who can afford to pay a higher price.

Plate 4. 2: Apple Mango Seedling Ready for planting

Source: Field Survey, 2021

Plate 4. 3: Mango Seedlings at Cheptebo Training Centre

Source: Field Survey, 2021

Okoth *et al*., (2013), reported that apple mango fruit has the most preferred flesh colour, flavor, taste, texture and overall acceptability therefore, suitable for fresh consumption and processing.

4.5.1.2 Fertilizer

Proper fertilization program in mango farming is mandatory in preventing a decline in yield and fruit quality along with occurrence of imbalance in nutrient status that leads to the biennial bearing phenomenon in mango plant. The study found out that most of the small holder farmers do not apply the inorganic and deficiency correctors fertilizers to their mangoes (70 %).

According an FGD participant in Biretwo,

> "…… *we use locally available organic manure from goats and cows because we cannot. Afford to buy manufactured fertilizer due to its high cost …"13th June, 2020.* As shown in plate 4.4

Further, the key informants from Cheptebo and TOT factories respectively recommended that farmers should apply a slow release fertilizer annually for each inche of trunk, five feet above the ground. Half of this fertilizer should be applied before flowering and not during flowering and the rest after the mangoes are harvested. This will enhance flowering and high yield.

The study concurs with Tewodros *et al* (2018) who argued that most of the growers did not apply fertilizers to their mangoes, though some applied varying amount of organic fertilizers made from compost and manure, the major reasons for excluding inorganic fertilizers were knowledge gap, cost, and inaccessibility to fertilizers.

Plate 4.4: Organic Manure Applied on Planted Seedling

Source: Field Survey, 2021

4.5.1.3 Mango Spraying

The study sought to establish the number of times that the mango farmers spray their mango trees. Various types of mangoes tree sprays are available that work to help increase overall plant health and fruit yield, as well as protecting the tree from harmful

diseases. This sprays include nutritional sprays, organic sprays, fungicide spray and flower- inducing spray (Michelle Wishhart 2020).

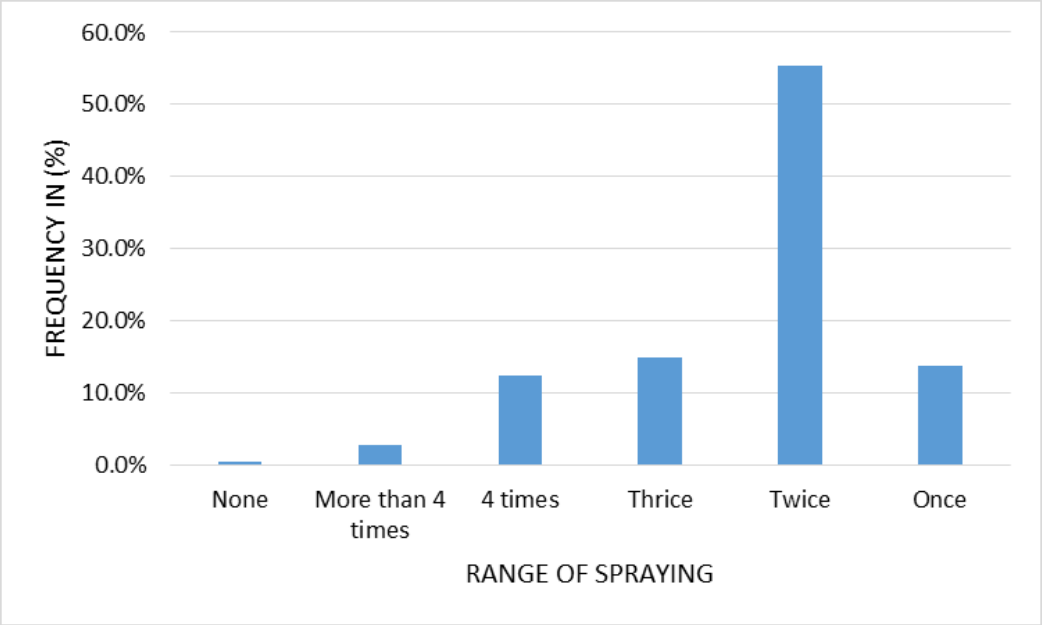


Figure 4.13: Mango Spraying

Source: Researcher, 2021

The study found out that over half of the farmers spray mangoes twice. It was further revealed through the key informant interview that most farmers prefer organic spray which is a mild alternative that can be sprayed on mango trees to bolster tree health, prevent pest and inhibit diseases like mildew and blight. The finding concur with FSD (2015) findings that established that many farmers do not spray their mango trees as per the recommended standards (4 – 6 times a year), citing a variety of reasons such as high cost and accessibility reasons.

4.5.1.4 Farm Equipment and Machinery

The study further sought to establish the spraying equipment that farmers use.

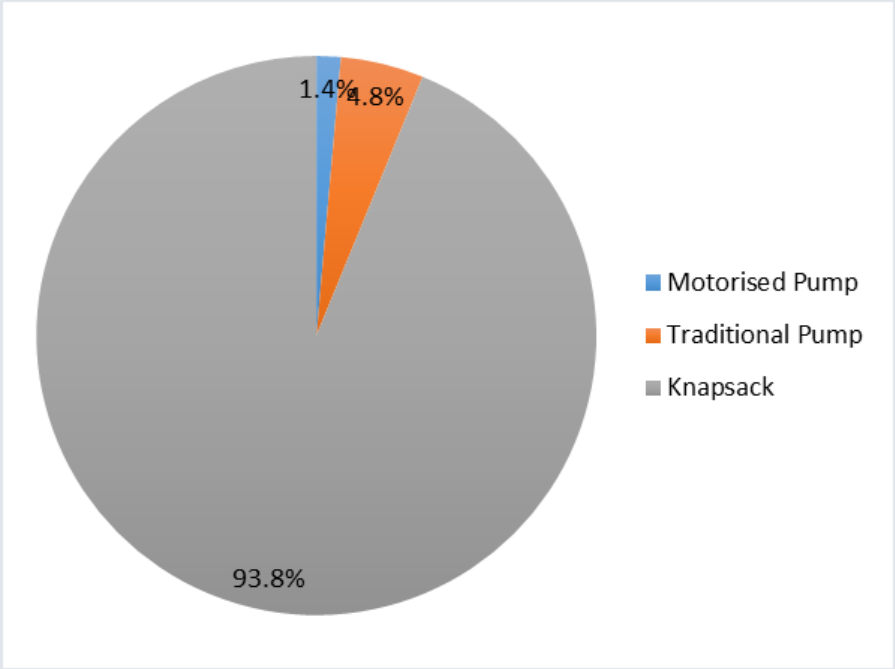


Figure 4.14: Farm Equipment and Machinery

Source: Field Survey, 2021

The study found out that 332 (93.8 %) mango farmers use knapsack spraying equipment. This is attributed to high efficiency, minimized chemical wastage, low labour intensity, less maintenance and continuous operation.

4.5.2 Resource Based Infrastructure

The resource based infrastructure generally includes sources of water and energy that mango farmers adopt. According to Mirjat *et al.*, (2011), proper irrigation is mandatory during critical stages such as flowering, fruiting, and maturity for successful growth and development of mango orchard.

Table 4.6: Access to Resource Based Agricultural infrastructure

Access	Mean	Std. Deviation	Skewness	Kurtosis
Electricity	2.1243	1.28902	-0.193	-0.974
Irrigation	2.9718	1.24108	-0.17	-0.97
Access to dam water	2.791	1.40671	0.032	-1.327

Source: Field Survey, 2021

The results indicate that the mango farmers do not have access to Electricity (Mean = 2.12 SD = 1.29, Skewness = -0.19, Kurtosis - 0.97). Through the FGD discussion it was found out that electricity is accessible to some households but purely for lighting and not for preservation or processing of mangoes due to high electricity bills and unavailability of equipments like refrigerator. However, it was revealed that mangoes are only processed at Cheptebo Training Center where most of the farmers sell their mangoes. However, it was found out during the field study that the TOT factory that is supposed to be processing the mangoes from Marakwet East was not operational due to conflict and insecurity.

The study also found out that the farmers don't have access to irrigation facilities (Mean=2.97, SD=1.24, Skewness=-0.17, Kurtosis=-0.97). The study found out through the key informant interview that irrigation is only possible for farmers living adjacent to Kerio river especially those in Biretwo and Kamnarok area. Most farmers continue to be almost wholly dependent on rainfall, which is highly unpredictable. Being an arid and semi-arid land area, the productivity is affected during drought season. This leads to substantial shocks in agricultural outputs. Therefore, the importance of irrigation stems from its ability to free farmers from these limiting factors.

It was observed, as shown below, that farmers pour water directly to the mango seedlings after planting.

Plate 4. 5: Planted Seedling

Source: Field Survey, 2021

Further, the study found out that they do not have access to dam water (Mean= 2.79, SD=1.41, Skewness=0.03, Kurtosis=-1.33). The study however found out through the FGD that there is a unique system of furrows on the steep of escarpments that provides water for irrigation. The furrows are managed by various clans who own, depend, and are responsible for its management. This clans include: *Kakimoi, Kapkirwon,Katemuko and Kachesek* among others. The clans share the water through, a meticulous plan that has been laid down. Since water resource in the region is scarce, and it should be shared equally this have led to each clan entitled to weekly use of the water from the furrows. They further pointed out that the entire Marakwet region is served by two water sources river Arror and river Embobut. An improved furrow is shown in plate 4.6 Water scarcity is a perennial problem in this region. It has been a recipe for resource-based conflict but rules and regulations were put in place to mitigate any form of conflict through the furrow system,

One key informant said that;

> "Since our area is arid and hilly, our forefathers came up with ways to draw and share water among the locals. They came up with the furrows which are trough-shaped made from stones, leaves and trees but now it made of stones and cemented The furrows drop down the escarpment to the valley, supplying water to farms based on the four legs of a cow representing the four clans. Two clans are entitled water for two years (Twii) two front legs of the cow. Then the remaining two (Chirkiande).

The art has stood the test of time and defied modernity.

Plate 4. 6: Locals at furrows Arror Ward in Kerio Valley, Elgeyo Marakwet County.

Source: Peter Ochieng, Standard August 11th 2021

4.5.3 Physical Infrastructure

The physical infrastructure in the study include road connectivity, transport, storage, processing and preservation. According to Effiong (2016), provision of efficient infrastructure is widely acknowledged as indispensable to agricultural progress. Increased availability of physical infrastructure would assist farmers to produce efficiently and generate more agricultural income from mango farming.

4.5.3.1 Road Connectivity

Road network is a key driver of socio economic growth in every country. This connectivity makes mobility and distribution of agricultural services and products faster and easier. The study found out that some of the roads were impassible especially the feeder roads during the raining season which explains why the common mode of transport was the use of the motor cycle as shown in plate 4.7

The FGD revealed that roads in the area are not tarmacked and the fruits easily go to waste because of the amount of time it takes to reach various markets. They indicated that they feel abandoned because the area produces the fruit in abundance, and the concerned authorities are doing nothing to tap this potentiality. The results imply that mango farmers in the region are not prospering as expected. This would lead to mango farming being seen as curse instead of a blessing.

Plate 4. 7: Feeder Road

Source: Field Survey, 2021

Kiprono and Matsumoto, (2014) argued that good road infrastructure could ease transportation, so as to shorten the delivery time and reduce costs, which will eventually affect the input prices. This will reduce the input price paid by farmers and it also increases their output price which can eventually increase farmers' revenue. Changes in input and output prices will result in the price ratio of input and output. Kumar *et al*, (2015), asserted that, for physical infrastructure, it is the accessibility of the services rather than their availability that is more important. Fakayode *et al* (2008), stated access is key to the efficient use of infrastructure; for instance, if there are communal grain silos in the area but the road networks are poor, farmers would not be able to access them, thus resulting in post-harvest losses.

4.5.3.2 Mode of Transport

The study sought to establish the mode of transport that the small holder farmers utilize. The findings indicate that use of motor cycle was the highest at 194 (54.6 %).

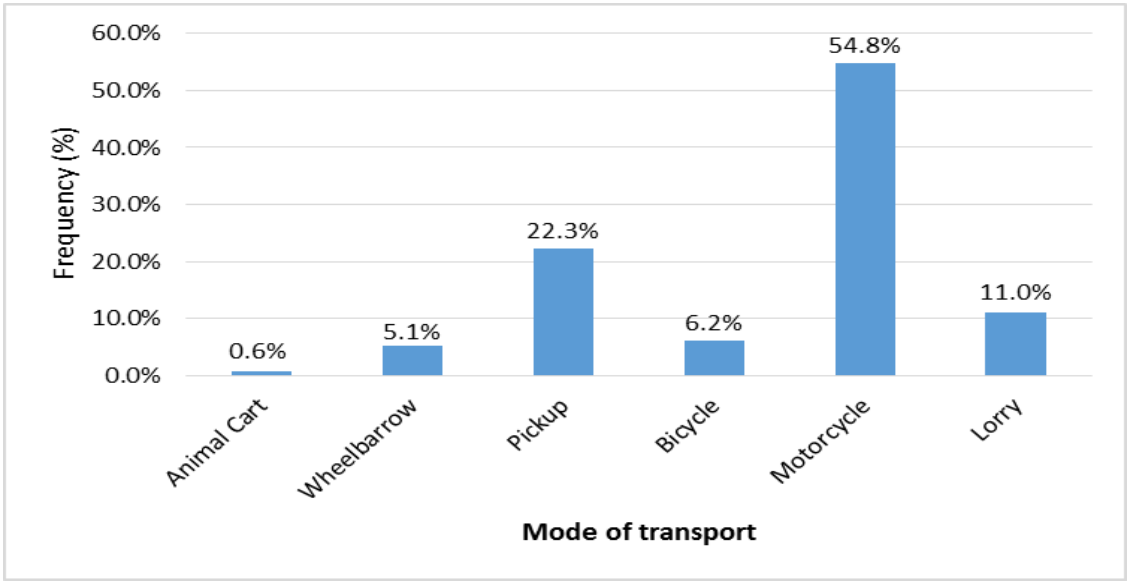


Figure 4. 15: Mode of Transport

Source: Researcher, 2021

On the mode of transport, 11 % rely on Lorries, 54.8 % motorcycle, 6.2 % bicycle, 22.3 % pickup, 5.1 % wheelbarrow and 0.6 % cart. Motorcycles are the most relied upon means of transport due to their flexibility to reach most of the areas, considering the terrain in Elgeyo Marakwet County; they are fast and easily available to the farmer. The only motorised transport services that people can rely on are motorcycle. Studies have shown that motorcycle often transport a high percentage of the passengers and small packaged mangoes moving between villages and markets (Kemtsop and Starkey, 2013; Njenga, Opiyo and Starkey 2013; Odero and Starkey, 2012; Willilo and Starkey, 2012). For example, on a rural road surveyed in Cameroon, indicate that 82% of 300,000 passenger movements a year were on motorcycles, as well as 74% of the estimated 33,000 tonnes of produce and goods going to and from markets (Kemtsop and Starkey, 2013). This is one reason why people closely concerned with rural development (village authorities, NGOs, extension officers, etc) also rated motorcycle very positively (Kemtsop and Starkey, 2013; Njenga *et al*, 2013).

The key informant further revealed that in Marakwet East non refrigerated trucks are used to transport mangoes however this exerts pressure on the fruits, hence softening the tissue and leads to deterioration. In addition, insufficient temperature controls reduces the shelf life of the fruit.

4.5.3.3 Storage

Storage is essential for extending the consumption period of fruits, regulating their supply to the market and also for transportation to long distances. The mature green fruits can be kept at room temperature for about 4-10 days depending upon the variety.

The development of improved mango storage methods that can maintain the fruit quality and enhance its shelf life is mandatory for the growers. According to Emongor,

(2015), storage of matured mango fruit in open air condition and above or below the optimum temperature requirement of the crop shortens the postharvest life and decline of the fruit quality due to rapid softening of the fruits which make the fruits susceptible to handling damages and postharvest pathogen.

Table 4.7: Storage Methods

Storage Methods	Mean	Std. Deviation	Skewness	Kurtosis
Agro processing plants	2.1215	1.39787	-0.306	-1.208
Storage	2.0565	1.38882	-0.178	-1.214

Source: Researcher, 2021

The results indicate that farmers do not have access to storage facilities. This imply that if not handle properly mango fruit can deteriorate and decay rapidly. It was observed during the field study that the two factories in Tot and Cheptebo were not operational hence a lot of losses since mangoes are perishable products. AFDB (2011) argues that even when farmers manage to achieve higher crop yields through input subsidies, favorable rainfall patterns, or irrigation infrastructure, their harvests are still at risk because of inadequate storage facilities.

4.5.3.4 Processing

According to FAO (2005), value addition in mango fruit involves processing of mangoes by making it into various products such as pickles, preserves, desserts, chutneys, mango juice, mango concentrate, mango jam, mango jelly and mango syrup/ canned mango. Agro-processing facilities that add value to products can include facilities for freezing and; fruit processing and various forms of bottling and packing. Agro-processing facilities are a means to prevent post-harvest losses, economic losses, helping farmer's access new urban and international markets.

The results a show that farmers have minimal access to agro processing plants (Mean = 2.12, SD = 1.39, Skewness = -0.31, Kurtosis-1.21). This implies that processing of mango fruit into the diverse shelf-stable products makes the season's fruits conveniently available to consumer all year round. One participant in the FGD stated that;

> "*The main challenge we have as mango farmers is the rotting of mangoes on the trees, this is because of plenty of mangoes and lack of technologies to help produce other products from the same. We hope that with the continuous operation of the processing plant in Tot mango losses will be the thing of the past".*

According to Kahan and Lehel (2009), without cold storage and related cold-chain facilities, farmers are often forced to collectively sell their produce immediately after harvesting, resulting in low prices due to the influx of mangoes in the market.

4.5.3.5 Preservation

The findings indicated that only 15.4 % of the farmers used refrigeration services. Through the FGD it was further found out that to some households who can access electricity do not preserve or process mangoes due to high electricity bills and missing required equipment's like refrigerator. The key informant indicated that the factories would have been of great help to farmers if was continuously in operation. Peyton, (2019) stated that advances in affordable off-grid cold storage technologies, combined with new initiatives to help rural farmers pool their resources, are creating ripe opportunities to reshape Africa's rural food systems and cut food losses. It is a two-step effort. The first step is helping rural farmers gain access to cooling technologies many running on solar power. The second is helping farmers use scale by pooling and cooling their crops to gain critical leverage in deciding when and to whom they sell their goods.

4.5.4 Institutional Infrastructure

Institutions can either drive or hinder an enabling environment in agricultural productivity. Strong institutions encourage participation in policy processes, build local capacity and establish a culture of learning. In contrast, weak institutions result in inadequate budgets, poor accountability systems, low technical capacity and limited investment and infrastructure (Pinto *et al.*, 2014).In this study institutional support include: Agricultural research, extension & education Technology, Information & communication services, financial services and marketing.

4.5.4.1 Agricultural Research, Extension & Education Technology

Agricultural Extension is very important in dissemination of information on innovation or new technologies to the farmer. It is important to improve farmer's method of production and enhance farm output.

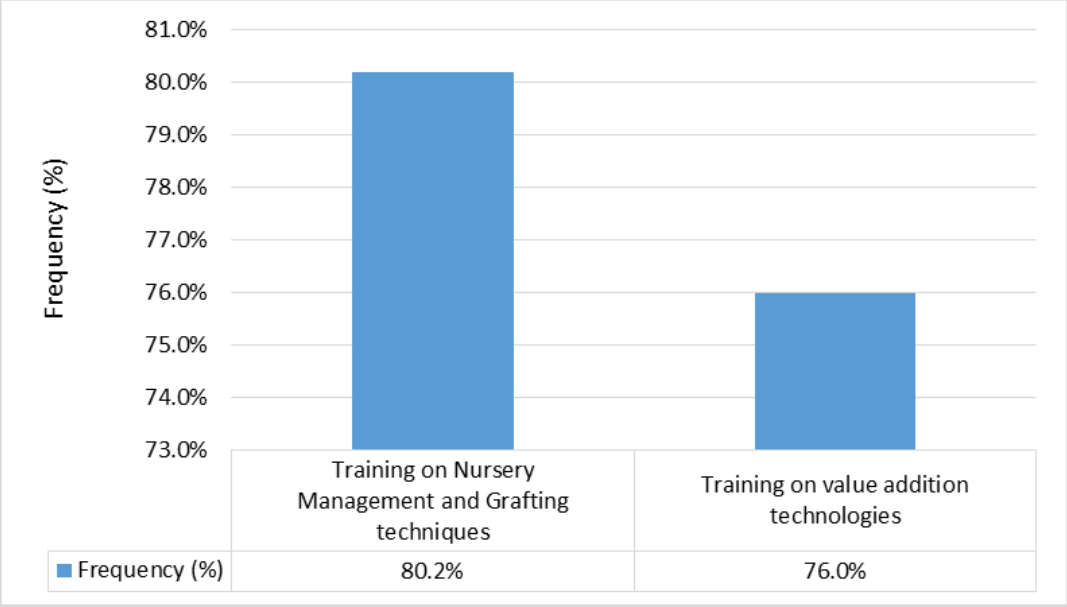


Figure 4. 16: Agricultural Research, Extension & Education Technology

Source: Researcher, 2021

Most of the smallholder mango farmers (80.2 %) indicated that they had undergone training on nursery management and grafting techniques. The findings also indicate that

76 % had undergone training on value addition technologies. Training of the farmers on these simple processing technologies can address seasonality issues and reduce post-harvest losses. It will also help to diversify use and markets of the fruits (Gitonga *et al*., 2014).

4.5.4.2 Information & Communication Services

According to Gwandu *et al.,* (2014) access to information means obtaining timely and relevant information and it further implies physical and economic access to written materials, print, mass media, extension, researchers, and any other form of communication. According to Obidike (2011), knowledge and information access is very essential to help the small holder farmers maximize their yields, production and post-harvest processing capacity.

The study further revealed that majority of the small holder mango farmers receive agribusiness information mostly from the extension officers 53.4 % followed by farmers group at 28.8 %, NGO at 26.6 % and Neighbour /friend/relative 15.3 %. It was also noted that the lowest rated source of information was, government officers 2 %, Mobile phone 4% and Radio/TV/Newspaper 11.9 %. Mangisoni (2006), found out that majority of farmers rely on friends, relatives and agricultural extension agents for market information.

While mobile technology is generally widely diffused in rural areas, the internet is not. High prices of computers and the Internet, combined with insufficient electricity, limit access to the internet in developing countries. Rural women have less access to ICTs than rural men because of higher illiteracy levels and insufficient financial resources to secure the use of ICTs (World Bank, 2011).

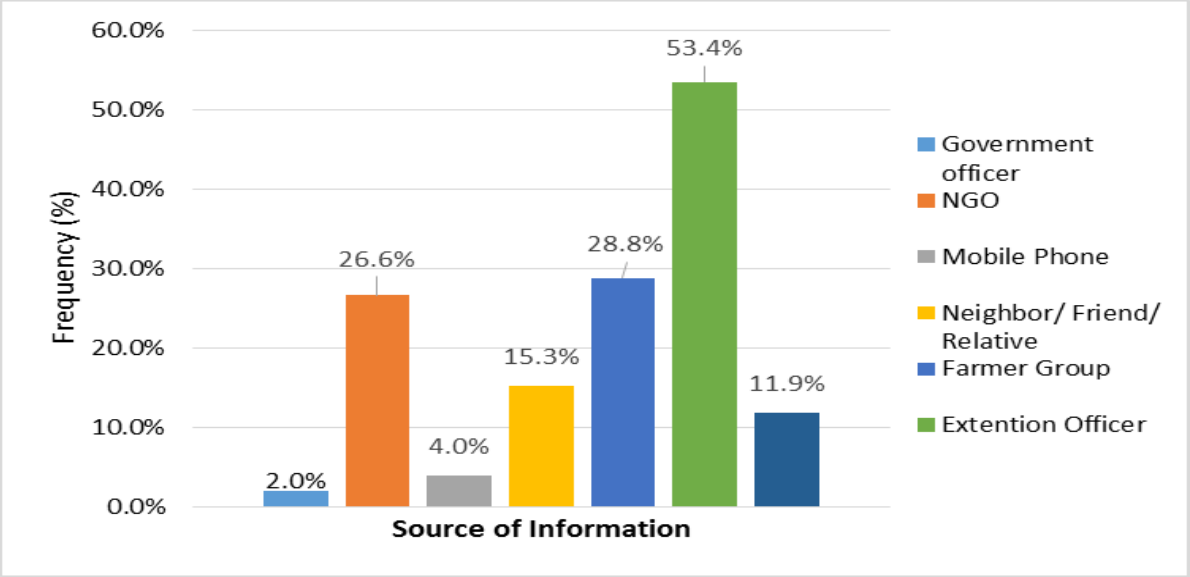


Figure 4. 17: Source of Information

Source: Researcher, 2021

4.5.4.3 Financial Services

Agriculture finance empowers poor farmers to increase their wealth and food production to be able to feed 9 billion people by 2050. It helps farmers provide market-based safety nets, and fund long-term investments to support sustainable economic growth. It also strategically important for eradicating extreme poverty and boosting shared prosperity. World Bank (2020).

4.5.4.3.1 Financing

Credit is an important factor in agricultural production especially to smaller holder mango farmers. Access to financing in mango farming enables farmers to take advantage of business opportunities, invest and save for the future and insure against risks.

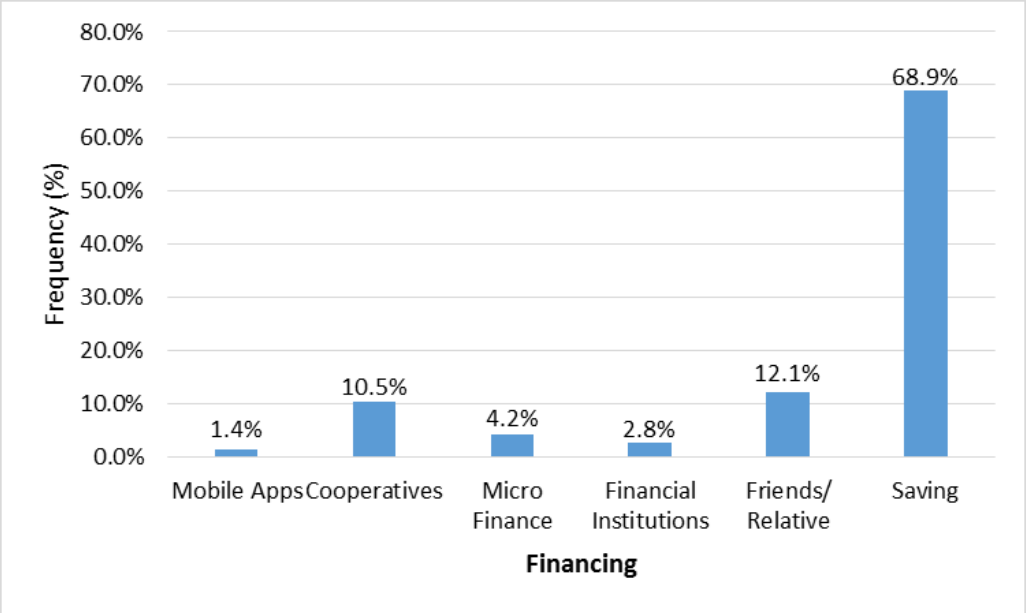


Figure 4. 18: Financing

Source: Researcher, 2021

The findings indicate that the mango farmer's main source of financing was their savings at 68.9 % (244), Friends/relatives 12.1 %, financial institutions 2.8 %, microfinance 4.2 % and cooperatives 10.5 %. Although mobile loans like KCB M-Pesa, M-Shwari and Tala were easily accessed, it was ranked the lowest at 1.4%. In addition, the financial institutions like commercial banks loans are equally avoided due to their requirements which most of them do not meet. A study by FSD (2015), found out that the most used financial service is savings, with an average usage by 81.7 % of those accessing financial services, followed by credit at 9%, remittances at 7.5 %, and insurance at 1.8 %. The fact that only 9 % of all farmers access any form of credit, with only 7.6 % accessing from formal sources (banks, MFIs and Sacco).

Further, key informant interviews revealed that most of the non-governmental organizations do not finance the mango farmers directly but instead they invest more in capacity building and input provision and market for the produce. Credit restriction has a negative impact on agricultural input and output, efficiency of agricultural production,

increasing income of farmer's agricultural resources allocation, productivity investments, and possibility of engaging non-agricultural self-employment with higher return (Ali *et al*., 2014, Takeshima and Yamauchi, 2012).

Without upfront investment farmers cannot obtain income diversity. The loan allocation reduces the possibility of farmers engaged in non agricultural self employment, but it increases the likelihood of farmer becoming wage labor in agriculture. Land ownership increases the likelihood that farmers engage in non agricultural self employed job, and its positive influence exceeds loan allocation's negative impact (Ali *et al*., 2014, Reyes and Lensink, 2011). Farmers without credit restriction use more fertilizer, improved seeds, extension advice than farmers with credit restrictions. Farmers without loan allocation use more hired labor, farmers with loan allocation use more family labors (Ali *et al*., 2014).

4.5.4.3.2 Barriers to Credit Access

Small holder mango farmers denied access to sufficient credit implies, that they are denied opportunities for current and innovative technologies and are particularly at risk associated with varying weather conditions and other challenges. Inaccessibility to credit by smallholder mango farmers as resulted in limited operations and technological input Njuguna and Nyairo (2015).

There are various barriers to credit as indicated in figure 4.19.

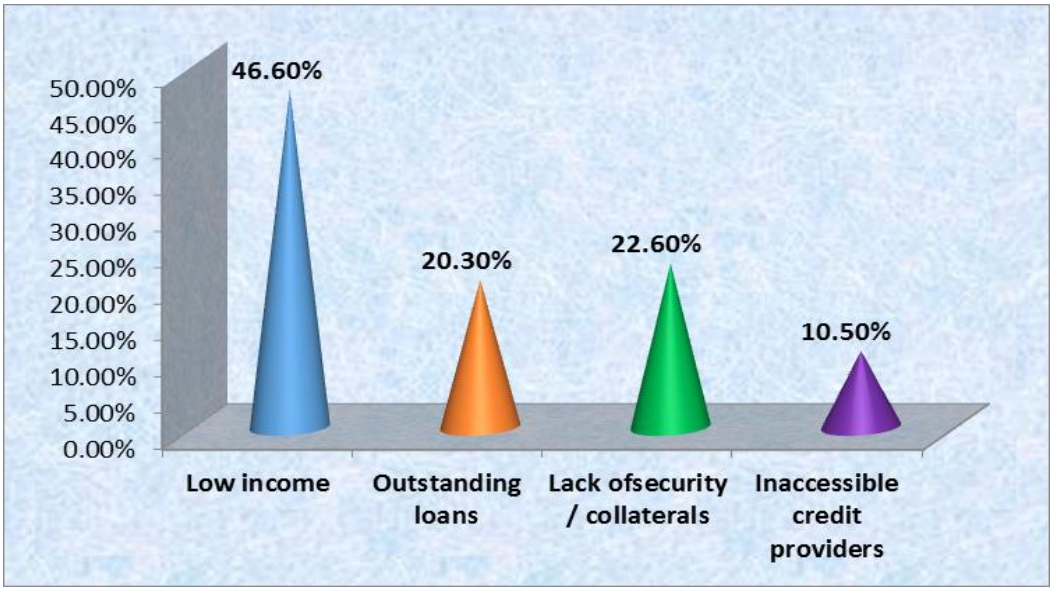


Figure 4.19: Barriers to Credit Access

Source: Researcher, 2021

Almost half of the farmers cited low income (46.6 %) as the main barrier to credit access followed by insufficient security/collaterals 22.6 %, high interest rates (20.3 %) and inaccessible credit providers (10.5 %). This shows that if farmers do not have the right collateral, chances of credit access is slim. In most cases the collaterals can be in form of guarantors, properties, pay slip from the local agricultural factories and cooperatives among others. Most small holder mango farmers face problems in providing loan collateral to financial institutions because they have either few assets, or these are in a form that is not liquid and hence not acceptable as loan security Jessop et al. (2013). According to World Bank the number one reason why individuals do not apply for or are denied loans is insufficient collateral and low income from mango produce. Additionally, credit rationing by financial institutions using interest rates has locked out most small holder mango farmers. Based on the earlier finding on source of financing the results showed that, financial institutions was rated at 2.8 %, microfinance 4.2 % and cooperatives 10.5 % respectively. This implies that small holder mango farmers cannot easily access credit since credit providers are inaccessible.

4.5.4.4 Marketing

Mango marketing involves a number of actors as the fruit is transported from the farm to the final consumer. Farmers can market their fruit themselves or through alternative actors in the marketing channel. Studies by ABD (2011) and Kehlenbeck *et al.*, (2010), have revealed that prices of mango fruits fluctuate by more than 100 %, making it very difficult for farmers to plan reliably. Major mango marketing challenges include: poor roads, inadequate post handing facilities, price fluctuations in internal and external markets and limited knowledge on value addition opportunities Serem (2010).

4.5.4.4.1 Mango Sorting

The findings indicate that 77.4 % of the farmers sort their mangoes. This imply that sorting of mangoes was a very important practice because the good quality mangoes are sold outside the Elgeyo Marakwet County and hence, it fetches higher prices. FGD revealed that sorting helps in separating varieties grown by small holder farmers, the characteristics that differentiate mango varieties are fruit shapes, size, aroma, sweetness, colour, fiber content, taste, seed size and resistance to diseases.

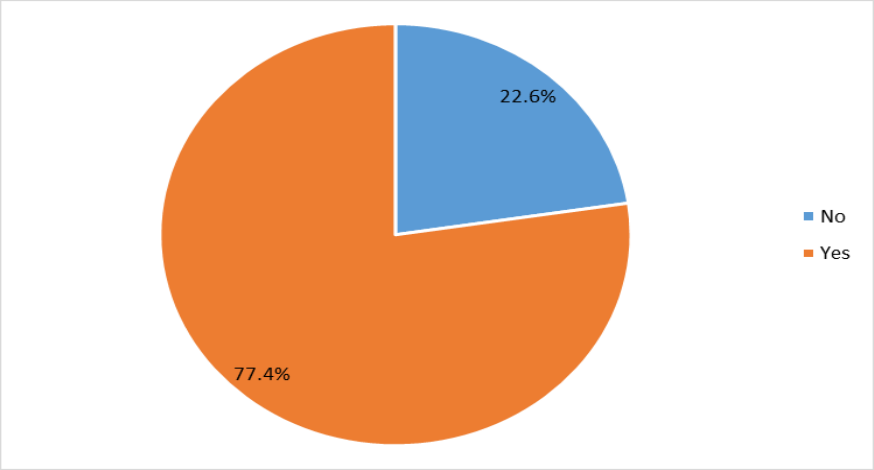


Figure 4. 20: Mango Sorting

Source: Researcher, 2021

4.5.4.4.2 Mango Market

Mango is highly seasonal and the harvest is only expected at certain times of the year depending on the local conditions. Most farmers harvest during this period hence the local market are flooded and the prices are low.

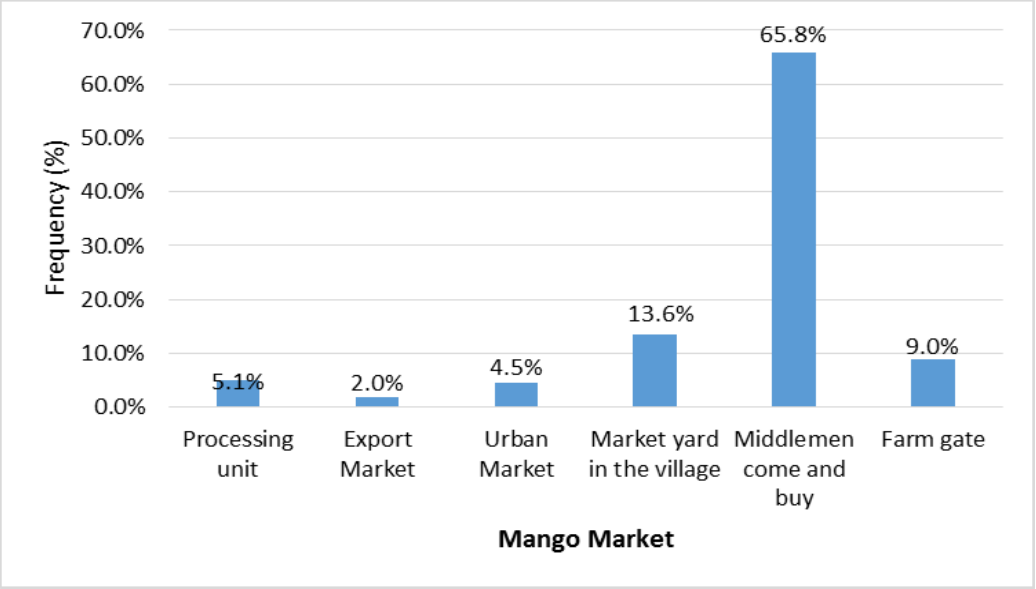


Figure 4. 21: Mango Market

Source: Researcher, 2021

The study found out that majority of the small holder mango farmers' sell their mangoes through the middlemen (65.8 %), market yard in the village (13.6 %), farm gate (9 %) Processing unit (5.1 %), urban market (4.5 %) and export market (2 %). Plate 4.8 show ripe mangoes ready to be plucked and Plate 4.9 show mangoes sold by the small traders along Iten Kabarnet Road. This agreed with findings by ADB (2011), where it was found that farmers were hardly involved in direct selling of their fruits but mostly through middlemen.

Plate 4.8: Ripe Mangoes

Source: Field Survey, 2021

Plate 4.9: Mangoes sold by the small traders along the road

Source: Field Survey, 2021

4.5.4.4.3 Middlemen and the Market

According to USAID (2015), middlemen tend to control the mango sector from purchasing of mango fruits in the farms, through ripening facilities and distribution networks to the markets. The study sought to establish the role of middlemen in marketing of the mangoes.

Table 4.8: Middlemen in Marketing

	Middlemen	Frequenc	Percentage (%)
1.	Middlemen provide cost convenient method of selling mango fruits.	267	75.4 %
2.	Middlemen have better access to the mango fruit market than farmers.	252	71.1 %
3.	Middlemen are more knowledgeable on marketing than mango farmers	265	75 %
4.	Do you think middlemen exploit mango farmers unfairly?	277	78 %

Source: Field Survey, 2021

The results indicate that middlemen provide the most convenient method of selling mango fruits 267(75.4 %). It was attributed to the fact that the middlemen use their own means of transport to reach the farmer down the valley. This finding concurred with those of USAID (2015), which showed that middlemen guaranteed continuous mango supply to the market and through them; new opportunities to particular market segments may be opened.

Likewise the study found out that middlemen have better access to the mango fruit market than farmers 252 (71.1 %). This agreed with findings by Sandika, (2011), that middlemen are important in marketing because they have better access to the markets than farmers.

Similarly, the results show that middlemen are more knowledgeable on marketing of mangoes than mango farmers 265 (75 %). According to Serem, (2010) farmers have low levels of education and therefore limited information on prevailing market situations as compared to middlemen. It explains why in many cases middlemen are more knowledgeable on marketing than the farmers.

The findings also indicate that middlemen exploit mango farmers unfairly 277 (78%). This agrees with Mututo (2017), that middlemen exploit mango farmers by paying very little for fruits while selling at high prices. According to Serem (2010), mango marketing in Kenya has faced numerous problems among them; poor infrastructure (roads), inadequate post harvest handling facilities, price fluctuation in internal and external markets and limited knowledge on marketing. Prices of mango fruits fluctuate from Ksh 25 to Ksh 5 per fruit, limiting farmers from making reliable plans from mango fruits income (ABD, 2011). In many cases, farmers receive very low income from their mango fruits sales in spite of these fruits selling at very high prices to the final consumers (Mututo, 2011). This may result to farmers abandoning the mango farming sector which may lower their economic levels. Mango fruit farmers are hardly involved in direct selling of their fruits to the final markets. Instead, middlemen go to the farm to buy the mango fruits from famers (ABD, 2011). Middlemen get larger share at the expense of the farmers who apparently have low level of education and limited information on the prevailing market situation.

USAID (2015) articulated that some farmers and middlemen may open new opportunities as they permit access to particular market segments. At the same time, the process of distributing market shares is accompanied by marginalization and exclusion, as middlemen may impose prohibitively high barriers on farmers in terms of short-run and long-run efforts needed for marketing (FAO, 2019). According to Mututo, (2011)

linking of farmers to markets is necessary in order to overhaul the sub sector because the mango market is mainly being controlled by unscrupulous middlemen.

One participant suggested through the FGD's, that

> ….. We have no capacity to take our mangoes to Cheptebo or Tot factories since it's far from where we stay and we are now forced to sell tell at exploitative prices to the middlemen. We need to form farmers groups to facilitate production and marketing of our mango fruits I feel we are exploited by middlemen because we don't have associations to champion for our issues". FGD held at on 14th June, 2020.

The findings are aligned to those of Andrea (2012) who suggested that organizing mango production through farmers groups minimizes the need for middlemen. Fischer and Qaim (2012) noted that farmer organizations have the potential to take over responsibilities for accessing agricultural extension, input provision and distribution, bulking, grading, selling, and even processing.

4.6 Stakeholders Involvement in Agricultural Infrastructure

The second objective was to evaluate the stakeholder involvement in agricultural support for small holder mango farming. The complexity of agricultural land use and food production systems also means that many different organizations have commercial or regulatory interests in farming and its possible health effects. All these need to be considered as potential stakeholders and participants in agricultural infrastructure. Non-governmental organizations have different objectives and roles within Elgeyo Marakwet County but those that have initiatives related to climate change include: World Vision, Tullow Oil Company, AIC Cheptebo Rural Development Centre, and Iten Integrated Environmental Conservation (IIEC) CBO CIDP (2018). World Vision has the resilience and nutrition project over and above the child support programme. Their interventions are not directly targeting climate change but provide support during

climate change disasters; they also improve livelihoods to help families cope with effects of climate change. They provide capacity building in terms of building awareness about climate change and strategies to recover from effects of climate change and in extreme cases, disasters. World Vision is involved in promoting conservation agriculture with initiatives like supporting building of terraces. They help put up water reservoirs and small irrigation infrastructure to help families in times of drought. The field offices are fully involved in planning but are restricted by insufficient resources.

AIC Cheptebo Rural Development Centre, a development arm of the AIC church has set up an agricultural development center where they train farmers on the best agricultural practices. They provide demonstrations on irrigation systems that are appropriate for smallholder farmers. A board and a management team drawn from both the church and the community, manage the organization.

Table 4.9: Stakeholders Involvement in Agricultural Infrastructure

	Stakeholders Involvement	Frequency	Percentage (%)
1.	The government and other stakeholders are providing subsidized inputs for farmers	267	75
2.	Various stakeholders support irrigation practices.	223	33
3.	The county government and other institutions promote and support farmer's unions and cooperatives.	264	75
4.	The government and other stakeholders has invested in road infrastructure in the region	288	81
5.	The county government is directly involved in streamlining mango prices.	147	42
6.	Various stakeholders create direct links to final consumers of mangoes through marketing.	164	46

Source: Field Survey, 2021

The findings indicate that 267(75%) agreed that the stakeholders are providing subsidized inputs for farmers. This imply that adequacy and timely supply of inputs like seedlings is central to the success of smallholder farming however, on many occasions it acts as an impediment for the full realization of maximum yields in farming when there is delay and inadequacy in production (Mazwi, Chambati, & Mutodi, 2018). The key informant interview revealed that Kerio Valley Development Authority (KVDA), NGOs, County government and Faith Based organization provides subsided seedlings to mango farmers.

Similarly, 223 (33%) agree that there is adequate access to water for irrigation. This can be attributed to the fact that farmers in Marakwet East in Endo ward depend on water from the furrows which is controlled and managed by different clans. World Vision is involved in promoting conservation agriculture with initiatives like supporting building of terraces. They help put up water reservoirs and small irrigation infrastructure to help families in times of drought. AIC Cheptebo Rural Development Centre, a development arm of the AIC church has set up an agricultural development center where they provide demonstrations on irrigation systems that are appropriate for smallholder farmers.

Further, the results indicate that the county government and local institutions support farmer's unions and cooperatives 264(75%). This implies that through extension services, training and capacity building the farmers get support through their unions and cooperatives. Institutions such as AIC Cheptebo Rural Development Centre, has set up an agricultural development center where they train farmers on the best agricultural practices.

In addition, the findings indicate that the government has invested in roads infrastructure in the region 288(81%).This indicates that the farmers are able to transport farm inputs to their farms and the produce to the market. It was revealed during the field study that trucks from as far as Kawangware Nairobi go through Nakuru down to the valley to pick mangoes from the farmers. The results also show less than half of the respondents indicate that there is streamlining of mango prices 147(42%). This affects the income that the farmers receive and it also means that as much as the farmers are investing more time in farming they do not get the real value from farming. The finding also indicate that 164(46%) various stakeholders create direct link to final consumers of mangoes through marketing this indicates that 54% are exploitation by the middlemen who have direct links than the small holder mango farmers.

4.7 Impact of agricultural Infrastructure on sustainability of Small Holding Farming

The third objective was to assess the effects of agricultural infrastructure on the sustainable smallholding mango farming. Agricultural infrastructure has the potential to transform the existing traditional agriculture or smallholder farming into a most modern, commercial and dynamic farming system in any country depending on agriculture (Isakson, 2014).

The findings indicate that availability of quality planting seeds has led to increased output 297 (84 %). The key informant interview revealed that Kerio Valley Development Authority sells grafted mango seedlings at KSh 120 to the farmers. Plate 4.6 shows a farmer planting a grafted mango tree seedling. Through the interviews, it emerged that one of the reasons for the low productivity is a large number of old mango

orchards that are in the age group of 30 years and above, which have either gone unproductive or showing marked decline in productivity. This is attributed to overcrowded and intermingled branches and meager foliage, allowing poor light penetration to growing shoots within the canopy. Moreover, growing mangoes by seeds takes longer to produce fruit and are more difficult to manage than those that have been grafted, thus mango tree grafting should be the preferred method of growing the fruit. Grafting provides the benefit of attaching different roots to trees to enable them to grow in soils where it normally can't grow. If you were to plant a tree where it shouldn't be planted naturally, it will have a shorter life. If you graft a tree using an appropriate rootstock, it will be better able to handle adverse conditions. Specific rootstock can be used to cope better with different soil types and soil conditions, such as heavy or clay soils, or resist particular diseases. It also takes a shorter time to grow and produce fruits. With grafting, one is certain about the organoleptic properties of the fruits that will be produced since the fruits to be yielded are essentially just clones.

Plate 4. 10: A Farmer planting a mango seedling

Source: Field Survey, 2021

Nearly 50 per cent of African farmers still spend five hours or more to the market. Not only are there few roads, but transport costs in Africa are among the highest in the world, reaching as much as 77 per cent of the value of exports (GoK, 2003 and Serem, 2010).

Relatively, the findings show that seasonal and tarmac roads can enhance the transportation of farm inputs and outputs at 231(65%). The findings concur with Kiprono and Matsumoto (2014), who argue that good road infrastructure could ease transportation, so as to shorten the delivery time and reduce costs, which will eventually affect the input prices. Torbjorn and Bharat (2012) argue that good road accessibility significantly reduces farm gate prices of manufactured goods and increases farm gate prices of agricultural goods.

The results also indicate that there has been a deduction in cost of transportation from farm to market due to availability of good transport networks 201 (57 %). According to Asher and Novosad (2016), efficient transportation infrastructure can lower the costs of labor-market participation, that is, travel time and cost, including search cost and thus, eliminates an important barrier to labor market entry. Further, better roads lower the transaction costs of farmers as inputs become more accessible and farm produce are more easily marketed. Greater mobility through telecommunications, facilitates communication between consumers and producers, permits entry into new and possibly more profitable opportunities (Hajir, Obeidat, Al-dalahmeh & Masa'deh, 2015).

In addition, 176 (50 %) of the mango farmers contacted, agreed that they have proper storage that helps for securing good prices and also acts as an insurance against distress sale of produce. This can be attributed to insufficient proper storage in the study area.

FAO (2013) posit that optimal practices in harvesting, storage and processing are crucial in maximizing the benefits of agricultural interventions

Further, 208 (59 %) of the respondents agreed that availability of cold storage protects the perishable produce from spoilage, besides, helps in getting higher income to farmers. Regasa *et al* (2019) point out that, due to insufficient storage, smallholder farmers are obligated to sell their produce only for three months. But, storage infrastructures like cold chain could help smallholders to ensure supply of quality mangoes and or at least they can minimize the incidence of huge tones of losses due to storage problems and maintain the quality of the produce.

Likewise, the results show 216 (61 %) agreed that the mango farmers are accessing agro processing facilities that add value to mango production. Kenya is among the leading producers of mango in Africa and consequently, there is increased output at the farm-level that does not find markets hence results to high post-harvest losses. Measures such as value addition have been introduced as an intervention to increase the shelf life of mango, proper handling, and market access.

Value addition is one of the diversification used in enhancing fast recuperation of investment and boosting farmer's income (Agwu, Anyanwa, and Kalu, 2015; Salvioni, Henke, and Vanni, 2020). The results also indicated that 204 (58 %) agreed that value addition, packing, branding and good marketing network of the mangoes adds to the income of the farmer. FSD (2015) revealed that most packing takes place for the export market at organized pack houses while there is very little packing being done for the domestic market. As most fruit goes directly to the fresh retail markets, the only storage takes place for the supermarkets and the export market. Value addition enables small-scale farmers to reduce post-harvest losses and thereby offering them opportunities to

maximize returns (Tobin, Glenna, and Devaux, 2016). Value addition is the process of converting a product from its original form to a more valuable form through creation of value and innovation (Oyewole and Eforuoku, 2019).

Some of the value-added products that can be made from mango fruits at the farm-level include; mango juices, dessert, sliced and packed, dried mango among others. Furthermore, value addition also implies changing a raw product into something new through storage, packaging, processing, and drying or any other type of process that differentiates the product from its primary form. There is though low level of value addition practices among small-scale farmers (Ntale *et al*., 2015). Value addition is achieved through innovation and coordination processes (Donkor, Onakuse, Bogue, and de los Rios Carmenado, 2018).

However, small holder farmers' interest to add value to their product through innovation and coordination is largely limited by the market environment, supportive services, processing technologies, infrastructure, institutional, economic, and socio-demographic factors (Gashaw, Habteyesus, and Nedjo, 2018). However, in mango production, there has been low adoption of value addition technologies among small-scale farmers which predisposes the produce to spoilage due to high perishability (Kennedy, 2015). In Kenya, statistics show that only 6 per cent of the small-scale farmers add value to their agricultural produce (Ntale *et al*., 2015). An interview with a KVDA Director revealed that two multi-million-shilling factories have been set up in Kerio Valley, Elgeyo Marakwet County to open up mango farming in the drought-prone area. One is a mango juice processing factory at Tot, in Marakwet East Constituency TOT and Cheptebo Rural Development Centre, Keiyo South Constituency as shown in plate 4.11

Plate 4.11: Tot Mango Factory

Source: Field Survey, 2021

In the same vein, the results indicated that 170 (48 %) of the respondents agreed that mango farmers do not have electricity in the valley which can help in pumping water for irrigation. Insufficient infrastructure like, electricity and road network, in most rural communities are other challenges that the farmers face (Obidike, 2011).

In addition, the findings show that slightly half of the respondents 183 (52 %) agreed that cooperative societies in the area helps farmers save their income as well as giving them loans. Farmers' organizations provide the platform for smallholder farmers to discuss issues for increasing the availability of infrastructure and engaging governments to fund projects on infrastructure development (DAFF, 2017). Similarly, Kumar *et al*, (2015), emphasized the role of cooperatives in ensuring efficient delivery of financial support in smallholder farmers.

The mango farmers also indicated that they don't get the market for their farm inputs as well as getting education on quality farm inputs through the farmers' unions 189(53 %). Shiferaw, Hellin & Muricho, (2011) opine that community-based organizations such as farmer organizations will find it is easier to assist farmers because of the mobility and ease of transportation and communications provided by good physical infrastructure.

Further, the results indicate that 175 (49 %) less than half agreed that there are financial institutions in the area which provide farmers loans with affordable interest during farming process. The farmers 207 (59 %) agreed that the availability of agricultural research facilities in the area has enhanced the quality production of mango outputs.

Lastly, the findings indicate 68 % (239) of the access to agricultural extension which has significantly increased adoption of modern input such as chemical fertilizer and improved seeds. Carlisle (2016) reported that farmers having access to good quality extension service are more likely to adopt sustainable agricultural practices. Membership of group influenced the probability of participation of farmers to value addition activities of the mango fruits. A plausible explanation for this is that membership of groups, help farmers obtain and understand more on market information. In addition, farmers in groups, can easily receive training on value addition, exchange, and generate new notions and learn more about the benefits of value addition. This finding agrees with Donker *et al.,* (2018) results that group membership had a positive influence on farmers' participation in value addition activities. Moreover, extension contacts on value addition influenced the probability of engaging in value addition activities. Extension services in agriculture act as an intermediary between researchers, governments, and farmers. The services provided also include information regarding agricultural commodity production, marketing,

innovations, agricultural commodity processing (value addition activities) as well as other opportunities available to farmers. Similarly, value addition was found to be influenced by extension services (Gashaw *et al*., 2018). Farmers' access to extension services plays a very critical role in the production activities of smallholder farmers, and extension officers are often the ones who share information with smallholder famers on programs to finance infrastructure (Anderson and Masters, 2007). So, the more the access to the extension service the more the farmer would be decisive on value addition.

4.8 Hierarchical Regression Analysis on Contribution of Agricultural Infrastructure

The study adopted a hierarchical regression analysis to examine the contribution of agriculture infrastructure on agricultural sustainability for the various constructs under study. A Hierarchical regression is a statistical method of exploring the relationships among, and testing hypotheses about, a dependent variable and several independent variables. This method was appropriate because the study had a very large number of potential predictor variables that required a determination of which variable had the most predictive power. It allowed the researcher to examine the contribution of each set of independent variables above and beyond the first group of independent variables.

4.8.1 Tests for Regression Assumptions

Before testing regression assumptions, univariate and multivariate assessment of outliers was done across all cases. Further, subjection to probability for the mahalanobis D2 all had values more than 0.001 confirming that there was no outlier. A value of D2 with low p value (< 0.001) was used as the criteria to reject the assumption that the case came from the same population as the rest (Hair *et al.,* 2010). Following the assessment

of outliers, the data set was tested for fundamental regression assumptions. According to Hair *et al.,* (2010), the assumptions of regression analysis are essential to ensure that the results obtained were actually representative of the sample so as to obtain the best results possible. The key assumptions tested were sample size, normality, linearity, multicollinearity, homoscedasticity and independence of errors (Hair *et al.,* 2010).

4.8.2 Sample Size

Sample size has the effect of increasing statistical power by reducing the sampling error. Larger sample sizes reduce detrimental effects of non-normality. Also, hierarchical multiple regression analysis requires that the minimum ratio of valid cases to independent variables be at least 5 to 1 (Hair *et al.,* 2006). Hence, the ratio of valid case 354 was deemed adequate given four independent variables that was included in the analysis (Tabachnick & Fidell, 2013).

4.8.3 Linearity Test for the Variables

Linearity was tested in order to check the actual strength of all the relationships. This was necessary so as to identify any departures from linearity which were bound to affect correlation. Knowing the level of the relationship among variables is considered as an important element in data analysis since linear models predict values which fall in a straight line by having a constant unit of change or slope of the dependent variable for a constant change of the independent variables. In this study, linearity was tested using correlation coefficient. The purpose of using correlation was to identify independent variables that provide the best predictions considered a prerequisite for running the regression analysis. An examination of correlations (Table 4.11) revealed that no independent variables were highly correlated, with the exception of certification of

planting seeds, prices of pesticides, roads and transport, agro processing plant, electricity, irrigation facilities and knowledge in marketing.

4.8.4 Normality Test for the Variables

The assumptions of normality was examined at univariate level (i.e. distribution of scores at an item-level) and at multivariate level (i.e. distribution of scores within a combination of two or more than two items). To identify the shape of the distribution in the study, Kolmogorov-Smirnov and Shapiro Wilks Tests were used (Shapiro and Wilk, 1965) which were calculated for each variable. In this respect if the p-value (Sig. value) of the Shapiro-Wilk Test is greater than 0.05, the data is normal. If it is below 0.05, the data significantly deviates from a normal distribution. Therefore since the P values for all the variables in the study were more than 0.05, then normality of the data was confirmed.

4.8.5 Multi Collinearity,

Multi-collinearity means that two or more of the independent variables are highly correlated and this situation can have damaging effects on the results of multiple regressions (Cooper & Schindler, 2006). Multi-collinearity can be detected with the help of tolerance and its reciprocal variance inflation factor (VIF). The cut-off point for determining multi-collinearity is a tolerance value that is more than 0.10 and a VIF value of less than 10 (Hair *et al.*, 2006; Ghozali, 2005). The collinearity statistics (i.e., Tolerance and VIF) were all within accepted limits, and therefore the assumption of multi-collinearity was deemed to have been met (Coakes, 2005; Hair *et al*., 2010). Results of the variance inflation factor indicates that all factors were less than 2.0 and the collinearity tolerance was greater than 0.76. The minimum threshold for the model

was reached and therefore the model qualified for a further analysis. The table 4.11 shows the variance inflation factor and the collinearity tolerance.

4.8.6 Homoscedasticity Test for the Variables

Homoscedasticity refers to the assumption that the dependent variable exhibits similar amounts of variance across the range of values for independent variables. The Levene's statistic for equality of variances was used to test for the assumption of homoscedasticity. Violation of homoscedasticity of variance is confirmed if the Levene's test statistic is found to be significant (alpha level of 0.05). The levene test statistics were above 0.05 (Martin and Bridgmon, 2012). The assumption of homoscedasticity of variance in this study was therefore supported.

Table 4. 10: Correlation and Collinearity Statistics

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlation	Collinearity Statistics	
	B	Std. Error	Beta				Tolerance	VIF
Seasonal and tarmac roads	0.01	0.015	0.034	0.649	0.517	0.035	0.976	1.024
Cost of transportation	0.094	0.049	0.107	1.907	0.057	0.101	0.837	1.195
Agro processing facilities	0.172	0.047	0.205	3.637	0	0.191	0.833	1.2
Seeds	0.05	0.063	0.043	0.805	0.421	0.043	0.914	1.094
Farm machinery	0.023	0.053	0.026	0.433	0.665	0.023	0.733	1.364
Proper storage	0.093	0.055	0.127	1.685	0.093	0.09	0.462	2.164
Pumping water for irrigation	0.041	0.026	0.095	1.616	0.107	0.087	0.766	1.306
Storage protects perishable produce	-0.01	0.056	-0.013	-0.18	0.857	-0.01	0.491	2.037
Value addition	0.096	0.054	0.115	1.767	0.078	0.096	0.529	1.891
Cooperatives societies	0.061	0.061	0.076	1.003	0.317	0.054	0.392	2.552
Farmers Union	0.176	0.059	0.224	3.001	0.003	0.161	0.405	2.467
Financial Institutions	0.227	0.06	0.274	3.785	0	0.201	0.428	2.337
Agricultural research facilities	0.137	0.058	0.148	2.351	0.019	0.127	0.567	1.763
Agricultural extension	-0.013	0.054	-0.014	-0.236	0.814	-0.013	0.686	1.459

Source: Field Survey, 2021

Variables that explain agricultural infrastructure were entered into four steps. In step 1, Agricultural sustainability was the dependent on physical based infrastructure which composed of; Agro processing facilities, seasonal and tarmac roads and cost of transportation. In step 2, input based infrastructure which consist of seeds and farm machinery added into the first model. In step 3, resource-based infrastructures was entered into the second model. The resource based infrastructure consisted of; pumping water for irrigation, storage protects perishable produce and proper storage. The last step consisted of adding institutional based infrastructure into model 3. Institutional infrastructure consisted of agricultural extension, agricultural research facilities, value addition, financial institutions, farmers union, and co-operative societies.

Table 4. 11: Model Summary of the Hierarchical Regression Equation

Model								
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**R Square Change**	**F Change**	**df1**	**Sig. F Change**
1	.274[a]	.075	.067	1.15875	.075	9.436	3	**.000**
2	.278[b]	.077	.064	1.16050	.003	.474	2	**.623**
3	.311[c]	.097	.076	1.15320	.019	2.473	3	**.062**
4	.487[d]	.238	.206	1.06887	.141	10.431	6	**.000**
a. Predictors: (Constant), Agro processing facilities, Seasonal and tarmac roads, Cost of transportation								
b. Predictors: (Constant), Agro processing facilities, Seasonal and tarmac roads, Cost of transportation, seeds, Farm machinery								
c. Predictors: (Constant), Agro processing facilities, Seasonal and tarmac roads, Cost of transportation, seeds, Farm machinery, pumping water for irrigation, Storage protects perishable produce, Proper storage								
d. Predictors: (Constant), Agro processing facilities, Seasonal and tarmac roads, Cost of transportation, Seeds, Farm machinery, pumping water for irrigation, Storage protects perishable produce, Proper storage, Agricultural extension, Agricultural research facilities, Value addition, Financial Institutions, Farmers Union, Cooperatives societies								
e. Dependent Variable: AS								

Source: Field Survey, 2021

The results in step 1 indicated that the variance accounted for (R^2) with the first independent variable equaled 0.075, (adjusted R^2 equals to 0. 067) which was significantly different from Zero (F (3, 350) = 9.436, P< 0.05.

In the second model R^2 was 0.077, the adjusted R^2 was 0.064 and the R^2 change was 0.003. This implies that the addition of the second variable (input-based infrastructure) did not positively affect the model. The f ratio (F (3, 350) = 0.474, and was not statistically significant at p < 0.05. The third model indicated that the variance accounted for (R^2) with the first three independent variables equal to 0.097 the adjusted R^2 equaled 0.076., which was significantly different from Zero (F (3,350) = 2.473, the change in variance accounted for (change R^2) which was equal to 0.019. In the fourth model, variables for the first three models formed the regression equation. The change in One Square was equal to 0.141 with an r-squared value of 0.238 indicating statistically significant from Zero (F (3,350) = 10 .43, P< 0.05).

It is therefore be concluded that agricultural infrastructure which consist of physical infrastructure, input based infrastructure, resource based infrastructure and institutional based infrastructure significantly affected the output on agricultural sustainability. It was noted that input based infrastructure did not significantly affect agricultural sustainability as compared to the other three major factors.

4.9 Challenges in the use of Agricultural Infrastructure

The fourth objective was to determine the challenges on the use of agricultural infrastructure on sustainable smallholding mango farming. According to IFAD (2011a) the productivity of small holder agriculture and its contribution to food security and poverty reduction depends on the services provided by well-functioning ecosystems,

including agricultural infrastructure, soil fertility, freshwater delivery, pollination and pest control among other.

Table 4. 12: Challenges in use of Agricultural Infrastructures

		Frequency	Percentage (%)
1.	Lack of certified and availability of quality planting seeds	249	70
2.	High price and Lack of timely availability of fertilizers	247	70
3.	Insufficient availability and High price of pesticides	259	73
4.	Insufficient skilled labour during peak seasons	234	66
5.	Insufficient information about recommended packaging	229	65
6.	High incidence of pests and diseases	280	79
7.	Insufficient irrigation facilities	267	76
8.	Post-harvest losses	175	49
9.	Insufficient availability of good grading systems for fruits	297	84
10.	Insufficient availability of agro-processing factory in the area	231	65
11.	Insufficient credit facilities	285	81
12.	Insufficient access to the market and marketing facilities at village level	255	72
13.	Low price of farm produce at the time of harvesting	274	77
14.	Insufficient storage facilities	277	78
15.	Insufficient cheap and efficient transport	263	74

Source: Field Survey, 2021

The results indicate that lean certification and availability of quality planting seeds is one of the main challenges that small holders of mango farmers face [249 (70.4%)]. The

FGD also confirmed that farmers often use inferior seedlings obtained by germinating mango seeds from indigenous varieties due accessibility of the local variety and due to a shortage of improved grafted planting materials however the ungrafted trees take much longer to bear fruit. According to Oxfam (2015), whereas grafted trees begin to bear fruit within 3 to 4 years; ungrafted trees will take at least 5 years to bear fruit, depending on the growing conditions. FSD (2015) pinpoints that many farmers obtain planting materials from uncertified sources because the majority of them have learnt to graft mango trees on their own, notwithstanding the negative impact of using rudimentary technologies on the viability of the seedlings and on productivity in the long run.

Further, another challenge that the farmers cited was high price and lack of timely availability of fertilizers 247 (70 %). FGD revealed that some farmers do not afford to buy the fertilizer and it will eventually lead to low yields. This finding agrees with Leake *et.al* (2015) who found that timely inaccessibility and high price of inputs is beyond the purchasing power of the farmers.

In addition, lack of availability and high price of pesticides is another challenge affecting small holder farming in Kerio Valley 259 (73 %). The focus group discussion revealed that farmers were also struggling to access high quality pesticides thus, leading to insect and disease invasion resulting in lower productivity and poor quality of yields. According to the Ministry of Agriculture (2010a), farmers use pesticides to control pests and diseases but the cost of pesticides is very high and unaffordable to most farmers leading to low application or adulteration to make the pesticide cheaper and this makes pesticides usage ineffective. Oxfam Kenya (2015) posits that mangoes have many devastating pests and diseases, which can result in total yield loss. Major pests include the fruit fly (*Bactrocera invadens*), seed weevil (*Sternochetus mangiferae*) and

mealy bugs (*Rastrococcus invadens*) and diseases like anthracnose and powdery mildew are common in almost all mango growing areas. In addition, DaSilva *et al* (2012), asserts that several mango diseases are attacking from seedling to maturity; and pre-harvest to postharvest depending on the environmental conditions of the region.

It was also revealed, through the key informant interview, that in organic farming systems, preventive methods based on proper crop and habitat management are encouraged. Direct methods of control are reserved for emergencies only. Synthetic insecticides and fungicides are not allowed in organic mango production. The most destructive mango pests are the mango seed weevil and the mango fruit fly, which are common nearly in all mango producing areas.

Similarly, insufficient skilled labour during peak seasons affects operations of smallholder's farmers 234 (66 %). The findings revealed that access to skilled labour especially for pruning, harvesting, and other technical activities proved to be very difficult. The findings were in agreement with those from FDGs which stated that, not getting skilled labour for timely pruning was seriously affecting canopy size control, which is key determinant to productivity increases. Furthermore, the results indicated that to avoid extensive bruising to fruit, harvesting procedure is very technical and needs skilled personnel to handle. FAO (2017) argues that insufficient proper training to farmers and unavailability of skilled labour to carry out the farm operations and post-harvest operations is hindering the better handling of produce. Ugese, *et al*, (2012) stated that mango fruit production constraints include high perishability of fruit, inadequate farm labour, low price and poor yield especially during peak seasons. Jawale & Ghulghule (2015) posits that scarcity of labour was a major constraint to Kesar mango growers in districts of Marathwada region.

The results also show that insufficient information about recommended packaging affects the marketing and prices of mangoes 229 (65 %).

Through the FGDs one participant said

> "….. *the produce is always much during peak seasons and most of the farmer's package mangoes in nets and wooden boxes or sacks because plastic crates which are stable and to clean which can also reduce wastage and damage of the fruits is unaffordable*…" 16th June, 2020

The findings concur with the observation by Sivakumar *et al.,* (2011), that, improper packaging, transport, and inadequate field handling practices of mangoes have significant effect which includes postharvest losses, organoleptic, nutritional and functional quality attributes of the fruits. They further revealed that, in their study, about 91 % of the growers transport their produce in synthetic fiber sacks while very few (8 %) use wooden boxes and transport to the market by animals like donkey, car and by the farmers themselves to the nearby village market. Tewodros *et al.* (2014), opine that plastic crates, which are stackable, stable, easy to clean and reuse can reduce damage of perishable crops from an average of 30 % to less than 10 %.

In addition, there is a high incidence of pests and diseases in mango farming which affects the output 280 (79 %). This indicates that pests and diseases affect mango production and reduces its quality and quantity. The results concur with Abdullahi *et al*., (2011), who argued that mango trees are subjected to severe attack with scores of insect pests. This relates to ripening fruits, with estimated yield losses caused in some cases by more than 50% depending on the season and management practices. Okorley *et al*, (2014) indicated that fluctuating market price of the fresh fruit, pests and diseases, especially the mango fruit flies, and inadequate funds were some of the major constraints to most mango farmers in the Dangme West District of Ghana.

The findings indicate that insufficient irrigation facilities affects mango farming 267 (76%). The findings concur with Van Melle & Buschmann, (2013), who found out that the major constraints facing mango farmers include quality issues, poor negotiation power, high transaction cost and insufficient irrigation infrastructures. Hussen & Yimer, (2013) opined that irrigation, water scarcity, pest and disease and technology limitation were some of the major constraints to mango production.

The results also show that most respondents (175, 49%) indicated that they experienced huge post harvesting losses. It was also observed during the data collection period that the farmers feed their cows with overripe mangoes as shown Plate 4.11. This is one of the coping strategies the farmers have adopted to reduce the cost of post-harvest losses.

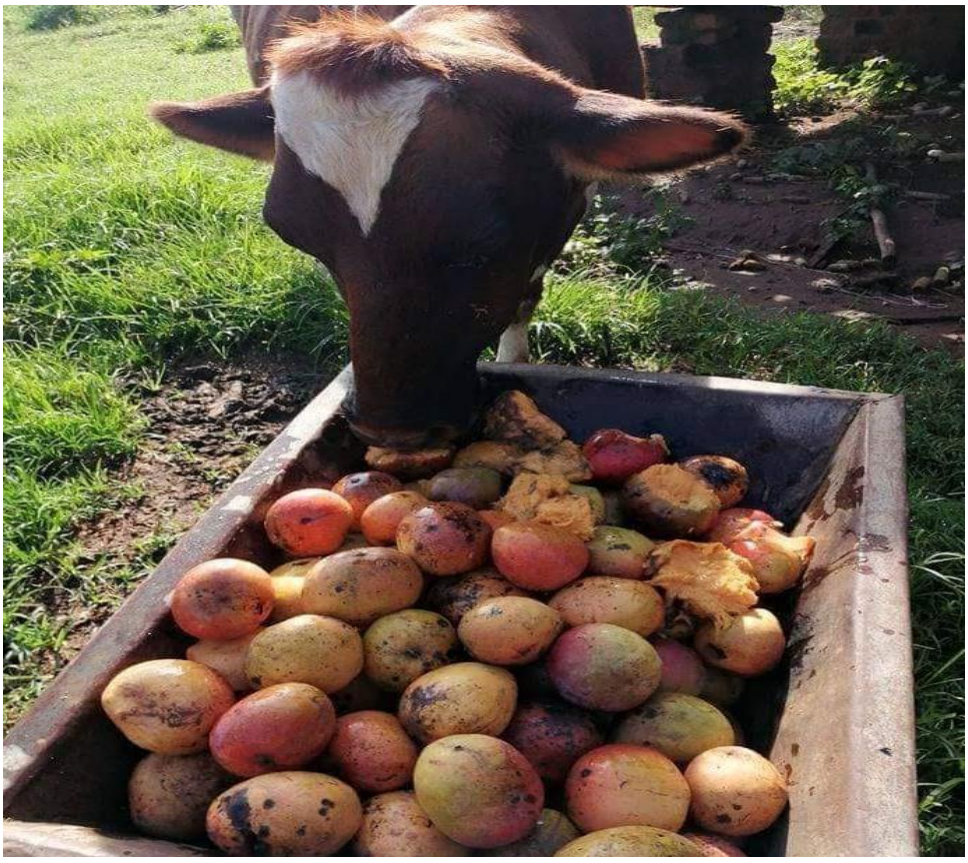


Plate 4. 12: A cow feeding on an overripe mango

Source: Field Survey, 2021

These findings are in line with the findings that the low price of farm produce at the time of harvesting was another factor that was cited by farmers 271 (77 %).This could be explained by the basic demand and supply law which indicates that there is high supply of the mangoes during the harvesting period which leads to low price due to low demand, thus leading to large losses because of the pricing or insufficient selling altogether (flooded market). Abu *et al*, (2011) posited that one major constraint in mango production is the high wastage of fruits during harvesting, particularly of the exotic mango varieties.

Further, the findings indicate that there is a insufficient availability of good grading systems for mango fruits 294 (84 %). According to Leake (2015), marketing problems faced by farmers and traders include insufficient market information, high competition during peak production period; which lowers price of mango, grading problem, quality problem because of premature harvest of mango, insufficient market linkage among value chain actors, price variation, problem of road and transportation.

In the same vein, there was lack of availability of agro-processing factories 231 (65 %). It was observed during the data collection period that Cheptebo Factory was not functioning while Tot Processing Plant had started functioning from October 2020. FAO (2009), opine that mango production is faced by serious challenges like limited access to information on technology in value addition, inadequate clean and quality planting material and limited access to information on technology in husbandry practices.

Capital and credit facilities play a critical role in small holder farming but the farmers in the study cited lack of credit facilities as an impediment to mango farming 285 (81%). Through the Key informant interview, it was revealed that mango most farmers did not

have access credit. Khapayi and Celliers (2016) results indicated that South African smallholder farmers have very limited access to credit as a result of low income, old age, insufficient collateral and low level of education which hinders them to meet basic credit requirements. Abdul-Razak *et al*, (2015) opined that some of the major challenges facing mango farmers were disease and pest attacks, low yields, bushfire outbreaks, insufficient cash credit, inadequate inputs, insufficient irrigation, no flexible contract terms and delayed payment. The findings by John and Emmanuel (2016) indicates that due to difficulty in accessing credit either from formal or informal sources, farmers have to depend on their own savings to finance their production business. Further, they indicate that credit conditions in terms of interest rate, collaterals, and loan processing procedures were not favourable making credit accessibility difficult. This subsequently impacted negatively on their productivity level, profit level and farm investment. The farmers also indicated that insufficient marketing facilities at village level affects the marketing of the mangoes 255 (72 %). The key informant interview revealed that out of 50,000 tons of mangoes harvested every season 34, 000 reach the market and other rot along the road and in most cases the middlemen decides the prices.

Berhanu and Moti (2010) opined that, a smallholder is market oriented if its production plan follows markets signals and produce commodities that are more marketable. Under a semi - commercial system, where both market and home consumption are playing a central role in production decision, all crops produced by household may not be marketable in the same proportion. Thus, households could differ in their market orientation depending on their resource allocation (Land, labour and capital) to the more marketable commodities.

The findings also indicate that insufficient storage facilities was another challenge faced by mango farmers 277 (78%). Cold storages increase the shelf-life of perishable products. FAO (2013), states that optimal practices in harvesting, storage and processing are crucial in maximising the benefits of agricultural interventions. It is estimated that over 20% of the physical harvest is lost due to bad storage and handling practices. In addition, inadequate handling and storage causes the loss of valuable micronutrients. The findings by Kyomugisha, Sebatta, and Mugisha, (2018) indicated that access to the storage facilities positively and significantly influenced the on-farm value addition of potatoes among small-scale farmers. Hence, access to the storage facilities by small-scale mango farmers increases the availability of the product over a long time and this makes it fetch higher prices in the market especially when demand is high. Therefore, maintaining micronutrient levels in commonly eaten foods should become an objective per se.

Lastly, insufficient cheap and efficient transport is another challenge experienced by mango farmers in Kerio Valley 263 (74.3 %).

The same was indicated through the FGD through one participant that

> "The *fruits were going to waste while those that reach the market fetch poor prices due to poor quality after hours of transport hitches".*

Regasa *et al* (2019) cite that transportation problems can lead to quality deterioration of mango due to the perishability characteristics of the produce. Since lack of availability of mango processing plants at the nearest area and storage bottle necks are widely present, the produce is exposed to sunlight and related factors that affect the quality of mangoes collected and as a result of transportation problems, exposure of the produce to the environmental factors increases. As a result huge tones of mango fruits are

rejected by the brokers and the damage effects, lowers the quality and thus the smallholder farmers are subjected to sell their produce at lower price.

The improvements of feeder roads, bridge construction, and rural road routine and spot maintenance results in increased participation of vendors at local markets, increased variety of available agricultural products and the geographic size of markets for agricultural products (Lucas *et al.*, 1995 and Torbjorn and Bharat, 2012). Good road accessibility significantly reduces farm gate prices of manufactured goods and increase farm gate prices of agricultural goods (Torbjorn and Bharat, 2012). Households with poor access to road are confronted with wider price bands and are less likely to participate in markets, so policies towards integrating remote areas with urban areas through infrastructure development are needed (Torbjorn and Bharat, 2012).

According to Regasa, Afework, Bekele and Dawit, (2019), institutions like access to market, market information system, microfinance/ credit and saving, seed (seedling) supply, consultancy services provided by development agents, cooperative and transportation facilities play a vital role in providing agricultural services. Associated with this, access to different institutional services might contribute commercialization of smallholder farmers. Hence, farmers nearest to the main market, infrastructure like main road and seasonal roads, agricultural inputs both adequately and timely are expected to enhance their market participation.

Provision of institutions such as market center at local level and input and market information delivering system which are assumed to play important role in improving the bargaining position of the producers and creating, lowering transaction costs, avoiding brokers and reducing the level of oligopolistic market type by creating competitive market. Strengthened and promoting equines managements and handling

should be better for transportation at local level and participation in mango market is necessary. Access to market information and quantity of mango produced should be promoted and strengthened for the further improvement of mango marketing and commercialization of smallholder mango producers in the area (Regasa, Afework, Bekele and Dawit, 2019).

During the focus group discussions, the following additional points outlined below were voiced out as hindering the use of agricultural infrastructure:

i. Lack of financial institutions to lend money to finance farmers operations
ii. Insufficient knowledge and skills on agriculture infrastructure
iii. Pests and diseases affecting yields of the products hence loss as the mango is one seasoned.
iv. High insecurity levels discouraging farmers
v. Insufficient water to irrigate the crops
vi. Middlemen frustrate the farmers who are forced to dispose especially during the harvesting season due to high supply and lack of market information.

The following suggestions were also raised in the FGD and by key informants to resolve the factors limiting use of agricultural infrastructure.

i. Awareness creation and training on modern farming skills
ii. Improvement of infrastructure such as roads and communications
iii. Dam building for irrigation
iv. Government to provide loans to the farmers to finance their operations
v. Provision of pesticides to control diseases and pests
vi. Improve security in the region by the government.

vii. Farmers to form cooperative societies to assist in the loan access, storage, processing market access that will enhance the bargaining power of the mango farmer.

4.8.1 Principal Components Analysis

Principal Component Analysis (PCA) was used to eliminate those items that had a low variance to sustain items that captured most of the variability among the services being provided. The 17 items on dynamics in the use of agricultural infrastructure by small holder mango farmers were administered to the 354 respondents. Respondents rated the extent to which they agreed with these challenges. Responses were on a Likert-type scale, ranging from 1 = “Strongly Disagree”, 2 = “Somewhat Disagree”, 3 = “Neutral”, 4 = “Somewhat Agree”, 5 = “Strongly Agree”. The study adopted this method in order to have smaller data sets that are easier to explore and visualize and make analysis of data much easier and gives a simplified interpretation.

4.8.1.1 Diagnostics

a) Data Screening

The data was screened for univariate outliers. There was no missing data. The minimum amount of data for factor analysis was satisfied, with a final sample size of 354 using list wise deletion.

b) Sampling Adequacy Test

This is a measure of homogeneity of variables since the value of KMO measures the adequacy of sampling and has become the standard test procedure for the factor analysis. The Kaiser-Meyer-Olkin (KMO) Test is a measure of how suited your data is for Factor Analysis (Stephanie, 2020). The test measures sampling adequacy for each variable in the model **and** for the complete model. The Kaiser-Meyer-Olkin measure of

sampling adequacy, tests whether or not the partial correlations among variables are small (Sharma, 1996).

Table 4.13: Kaiser-Meyer-Olkin and Bartlett's Tests

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.928**
Bartlett's Test of Sphericity	Approx. Chi-Square	**3417.953**
	Df	**136**
	Sig.	**.000**

Source: Field Survey, 2021

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .928, above the commonly recommended value of .6 hence allowing for PCA (Pallant, 2011). Additionally, the Bartlett's test of sphericity was significant ($\chi 2$ (354, 136) = 3417.95, $p < .05$). The Bartlett's sphericity test (Bartlett, 1950) tests the null hypothesis that the correlation matrix is an identity matrix (all correlations are zero). A probability (Prob) value greater than 0.05, prohibits the performance of PCA.

(c) **Communalities**

Table 4.14: Communalities

Communalities		
	Initial	Extraction
Certification of planting seeds	1.000	.605
High price	1.000	.545
Lack of availability and high prices of pesticides	1.000	.594
Agricultural labour	1.000	.585
Insufficient recommended packing	1.000	.632
High Incidences	1.000	.613
Proper plant protection equipment	1.000	.588
No irrigation facilities	1.000	.497
Insufficient Access to extension services	1.000	.546
Insufficient good grading system	1.000	.634
Insufficient availability of Agro-processing factory	1.000	.639
Insufficient capital resources	1.000	.692
Insufficient credit availability	1.000	.634
High cost of credit	1.000	.571
Insufficient marketing facilities	1.000	.523
Low price at harvesting	1.000	.540
Insufficient storage facility	1.000	.648
Extraction Method: Principal Component Analysis.		

Source Field Survey, 2021

Communalities indicate the amount of variance in each variable that is accounted for. The communality shows how well this variable is predicted by the retained components. Table 4.15 shows that the communalities were all above 0.5 further confirming that extracted components represent the variables well. Given these overall indicators, factor analysis was deemed to be suitable with all 17 items.

d) Total Variance Explained for Agricultural Infrastructure use

The Table 4.16 below shows the total variance explained for the dynamics in use of agricultural practices when running the PCA.

Table 4. 15: Total Variance Explained for Agricultural Infrastructure use

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.111	47.710	47.710	8.111	47.710 %	47.710
2	1.576	9.272	56.982	1.576	9.272 %	56.982
3	.951	5.593	62.576			
4	.902	5.304	67.880			
5	.790	4.648	72.528			
6	.689	4.056	76.584			
7	.539	3.171	79.755			
8	.474	2.790	82.545			
9	.462	2.717	85.262			
10	.418	2.461	87.722			
11	.400	2.352	90.074			
12	.376	2.214	92.289			
13	.316	1.858	94.147			
14	.302	1.774	95.921			
15	.249	1.464	97.385			
16	.226	1.331	98.716			
17	.218	1.284	100.000			

Extraction Method: Principal Component Analysis.

Source: Field Survey, 2021

Principal components analysis was used because the primary purpose was to identify key challenges on the use of agricultural infrastructure by small holder farmers. Final Eigenvalues indicated that the first two factors explained 47.7 % and 57.98 % of the variance respectively. Solutions for the 3rd to the 17th factor were each examined using varimax and oblimin rotations of the factor loading matrix. The two-factor solution, which explained 57.98 % of the variance, was preferred because of the 'levelling off' of Eigenvalues on the Scree plot (Figure 4.20 below) after two factors. Higher scores indicated greater challenges in the use of agricultural infrastructure. Approximately normal distribution was evident for the composite score data in the current study, thus the data was well suited for parametric statistical analyses.

Varimax rotation with Kaiser Normalization solutions was examined for the final solution. Varimax is orthogonal rotation (used for uncorrelated factors). Gorsuch (1983) says "If the simple structure is clear, any of the more popular procedures can be expected to lead to the same interpretations." Initially, principal component analysis revealed the presence of two components with eigenvalues exceeding 1. An inspection of the scree plot revealed a clear break after the second component as shown in Figure 4.21 below.

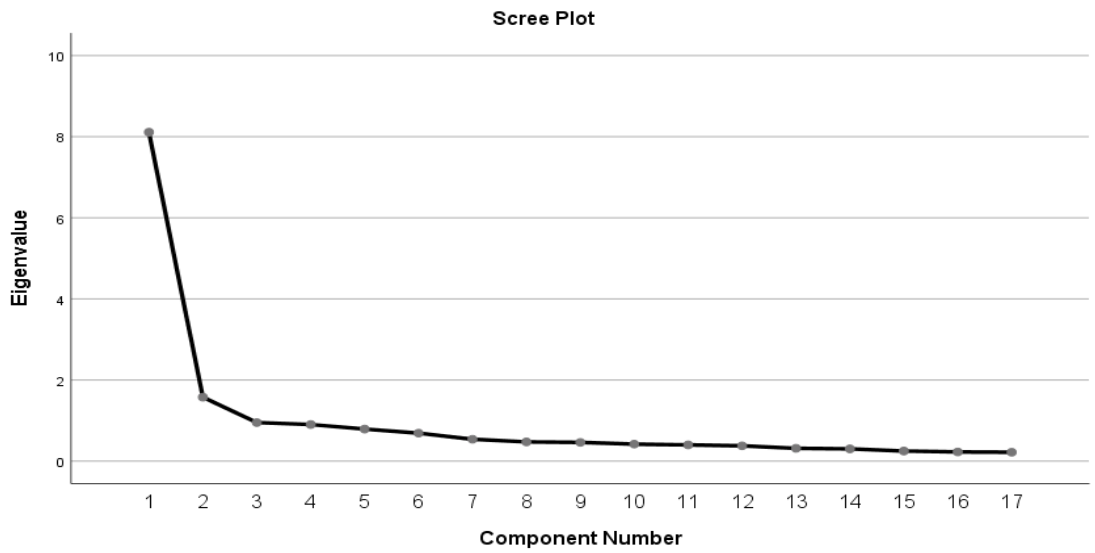


Figure 4. 22: Scree Plot

Source: Researcher 2021

This is a rough bar plot of the eigenvalues. It gives a quick graphical impression of the relative size of each eigenvalue. The Scree plot is as a method of determining how many components to retain. Cattell (1966) defined scree as the rubble at the bottom of a cliff. He adds that when using the scree plot, one must determine which eigenvalues form the "cliff" and which form the "rubble." Components that make up the cliff are left. Cattell and Jaspers (1967) further suggest keeping those components that make up the cliff plus the first component of the rubble.

The scree plot shows that the first two components have the highest variance. Cumulatively, the first two components account for over 57.98% of the variation. This inspection confirms with the PCA and therefore forms a good basis for parametric statistical analyses. Based on the final solution for PCA, the two components that accounted for about 57.98 percent of the variance were; inadequate certified and availability of quality planting seeds and high price and inadequate timely availability

of fertilizers. This implies that these two components are the major challenges experienced by small holder mango farmers in the study area.

4.10 Structural Equation Model

4.10.1 Partial Least Squares Structural Equation Modelling (PLS-SEM)

This study adopted PLS, based structural equation modelling for the data analysis. Hair *et al*., (2014) opines that this method is useful for causal-predictive analysis and does not involve assumptions of homogeneity in variances and covariance of the dependent variable. It also can simultaneously test the structural and the measurement models, providing a complete analysis for the interrelationships. The model was appropriate because it makes minimal demands on the data distributions, sample size, and measurement scales (Hair *et al*., 2014).

The study sought to establish the existing relationship between key latent variables that affect agricultural infrastructure using the partial least square structural equation (PLS-SEM) modeling method. The path model's analysis consists of the structural model and the measurement models.

4.10.2 Structural Measurement Model

Confirmatory tetrad analysis was conducted to ascertain the correct measurement model specification. Confirmatory tetrad analysis allows distinguishing between formative and reflective measurement models Gudergan *et al*., (2008). Additionally, a bootstrapping method was used to determine the significance levels of the loadings, and path coefficients (Gholami, Sulaiman, & Ramayah, 2013).

4.10.3 Agricultural Infrastructure for Sustainability

The study sought to establish the relationship between various variables of agricultural infrastructure on agricultural sustainability.

4.10.3.1 Diagnostics Tests

4.10.3.1.1 Factor loading, Construct Reliability and Validity

Hair *et al*. (2014) recommends the assessment of the reflective measures using both convergent and discriminant validity. As indicated in Table 4.18 the measurement models presented the factor loadings, average variance extracted (AVE) and composite reliability (CR) and Cronbach's alpha were used to assess internal consistency reliability and convergence validity (Hair *et al*., 2016). As shown, most of the loadings for the reflective items exceeded the recommended value of 0.5 (0.708) 2. However six indicator items such as INP3 (Certification of planting seeds), INP4 (High price of input), INP5 (Inadequate availability and high prices of pesticides), INS1 (Knowledge in marketing, PHY3 (Seasonal and tarmac roads) and RES4 (Pumping water for irrigation) were removed because it did not meet the minimum factor loading condition.

To test the reliability of the constructs, the study used Cronch bach alpha, composite reliability (CR & HMTM ratio). Since the values were greater than .8, the data was considered to be reliable for further analysis. All the CRs values were higher than the recommended value of 0.700 (Faraday and Plummer, 2005) α exceeded 0.700 threshold. Convergent validity was accepted because average variance extracted AVE was over 0.500. The study further established whether there was a problem of collinearity analysis through variance of inflation factor (VIF). Based on the results, all the constructs did not have a problem of multicollinearity since the values were less < 5. After testing for collinearity, the model established that the variables that had violated

the minimum threshold in factor loading also violated the minimum threshold in collinearity.

Table 4. 16: Reliability and Convergent Validity Assessment Results of Agricultural Infrastructure

Construct	Items-	Outer loadings	Cronbach's Alpha	rho_A	(CR)	AVE)	VIF
Input Based	INP1	0.863	0.370	0.399	0.755	0.609	1.054
Infrastructure	INP2	0.687					1.054
Institutional Based	INS2	0.851	0.645	0.706	0.800	0.575	1.275
infrastructure	INS3	0.775					1.289
	INS4	0.633					1.229
Physical Based	PHY1	0.758	0.830	0.889	0.865	0.519	1.477
Infrastructure	PHY2	0.803					1.584
	PHY4	0.612					1.653
	PHY5	0.780					2.180
	PHY6	0.681					1.984
	PHY7	0.672					1.855
Resource Based	RES 1	0.689	0.631	0.635	0.803	0.577	1.130
infrastructure	RES2	0.803					1.370
	RES3	0.782					1.401

Source: Field Survey, 2021

4.10.3.1.2 Discriminant Variability

In the study the discriminant validity was also tested following the discriminant validity criterion of Fornell-Larcker. It was examined by comparing the correlations between constructs and the square root of the AVE for that construct.

Table 4. 17: Discriminant Variability (Fornell- Larcker Criterion)

	AGR I	IPS	INS	PHY	RES
AGR I	1.000				
IPS	0.175	0.780			
INS	0.423	0.470	0.758		
PHY	0.527	0.461	0.707	0.721	
RES	**0.606**	**0.194**	**0.544**	**0.676**	**0.760**

Source: Field Survey, 2021

The results show that the square root of the AVE is higher than the correlation with other constructs indicating adequate discriminant validity (Hair *et. al.*, 2014). Thus the reflective measurement model demonstrated adequate internal consistency reliability, convergent validity and discriminant validity**.**

4.10.3.1.3 Heterotrait-Monotrait Ratio (HTMT)

Table 4. 18: Heterotrait-Monotrait Ratio (HTMT)

	AGR I	IPS	INS	PHY	RES
IPS	0.282				
INS	0.493	0.974			
PHY	0.490	0.845	0.974		
RES	0.759	0.379	0.805	0.864	

Source: Field Survey, 2021

The Heterotrait-Monotrait ratio was tested and the values were < .9 for all constructs and therefore the model passed all diagnostic tests for PLS-SEM analysis. Henseler *et*

al., (2015) and Kline, 2011), argue that the heterotrait-monotrait (HTMT) ratio of correlations should not have value exceeding .85.

4.10.3.1.4 Model Fit

In the study, to assess the overall quality of the adjustment model, a Goodness-of-Fit (GoF) indicator was calculated, which is given by the geometric mean of the average R^2 and average AVE (Ringle, Wende & Will, 2005).

Table 4. 19: Model fit (Goodness-of-Fit)

	Saturated Model	**Estimated Model**
SRMR	0.110	**0.110**
d_ULS	1.464	**1.464**
d_G	0.441	**0.441**
Chi-Square	896.457	**896.457**
NFI	**0.597**	**0.597**

Source: Field Survey, 2021

According to the results the calculated value was 0.597, which indicated that the model was well adjusted, since values above 0.36 are considered good for areas such as social and behavioural sciences (Hair *et. al*., 2013).

4.10.3.2 Infrastructure Variables and Agricultural Infrastructure

The study sought to establish the existing relationship between key latent variables that affect agricultural infrastructure.

Table 4. 20: Infrastructure Variables and Agricultural Infrastructure

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
INP-> AGRI	0.053	0.064	0.073	0.725	**0.468**
INS-> AGRI	0.002	0.000	0.088	0.028	**0.978**
PHY-> AGRI	0.223	0.220	0.101	2.195	**0.028**

RES->AGRI	**0.424**	**0.420**	**0.069**	**6.161**	**0.000**

Source: Field Survey, 2021

As it can be seen from the Table 4.22, that two of the factors were statistically significant (p= 0.028 and 0.000, respectively at p<0.05) while two were not statistically significant at p=0.468 and p=0.978. It can therefore be observed that physical infrastructure and resource based infrastructure have a positive impact on agricultural infrastructure. However, it was noted that factors related input based and institutional infrastructure did not have any impact on agricultural infrastructure.

The following Figure 4.21 shows a model for the analysis of agricultural infrastructure and the other latent variables.

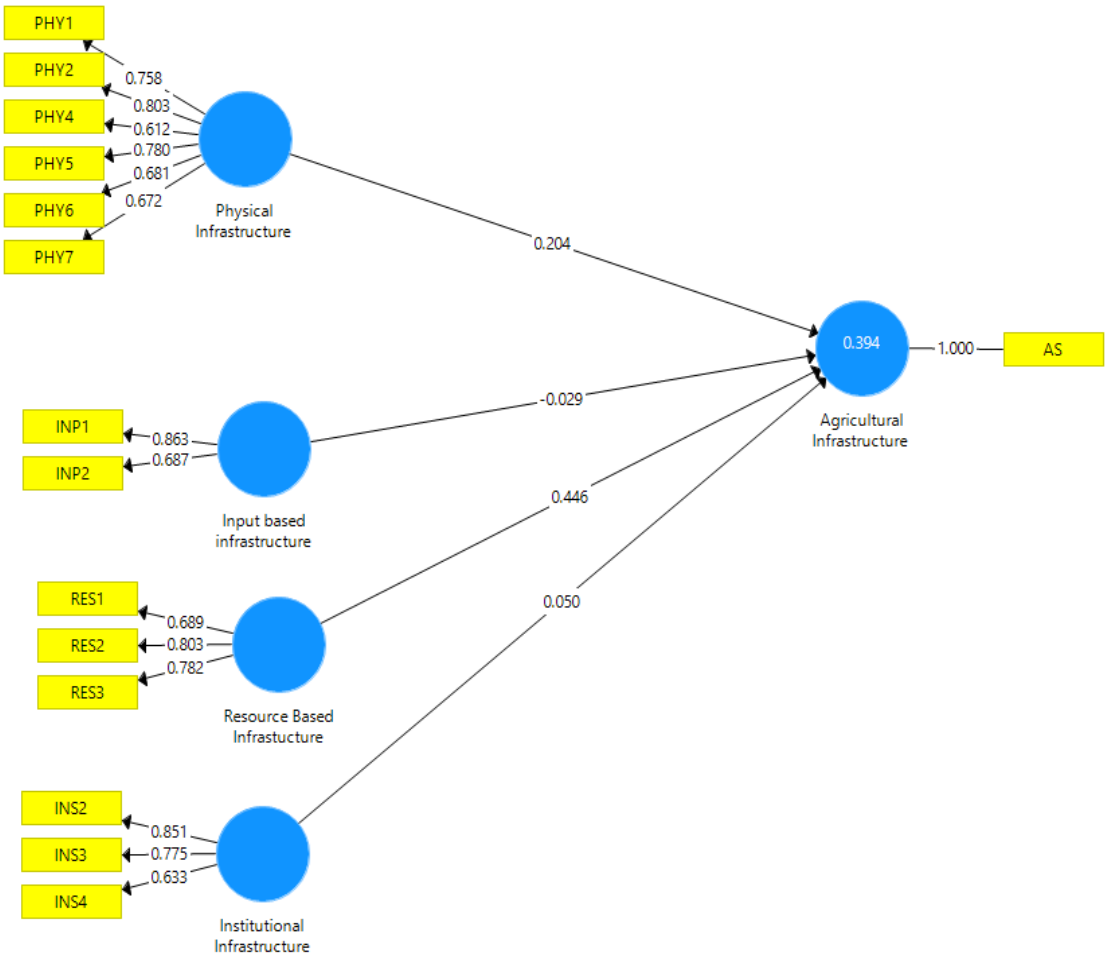


Figure 4.23: Infrastructure Variables and Agricultural Infrastructure

Source: Researcher, 2021

Mediation

A mediating effect is created when a third variable or construct intervenes between two other related constructs. Direct effects are the relationships linking two constructs with a single arrow; indirect effects are those relationships that involve a sequence of relationships with at least one intervening construct involved. Thus, an indirect effect is a sequence of two or more direct effects (compound path) that are represented visually by multiple arrows. This indirect effect is characterized as the mediating effect. Table 4.21 and figure 4.21 gives a summary of infrastructure stakeholder involvement (mediating variable) on the constructs under study.

Table 4. 21: Infrastructure Variables and Agricultural Sustainability

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
INP*MM -> Agricultural Infrastructure	0.097	0.098	0.068	1.429	**0.153**
INS*MM -> Agricultural Infrastructure	-0.204	-0.201	0.074	2.763	**0.006**
Input based infrastructure -> Agricultural Infrastructure	0.053	0.064	0.073	0.725	**0.468**
Institutional Infrastructure -> Agricultural Infrastructure	0.002	0.000	0.088	0.028	**0.978**
MM -> Agricultural Infrastructure	-0.099	-0.096	0.081	1.231	**0.218**
PHY*MM -> Agricultural Infrastructure	-0.015	-0.021	0.082	0.178	**0.859**
Physical Infrastructure -> Agricultural Infrastructure	0.223	0.220	0.101	2.195	**0.028**
RES*MM -> Agricultural Infrastructure	-0.141	-0.141	0.067	2.119	**0.034**
Resource Based Infrastructure -> Agricultural Infrastructure	**0.424**	**0.420**	**0.069**	**6.161**	**0.000**

Source: Field Survey, 2021

The results in Table 4.23 show the values of the original model and the mediated model. The original model shows that two variables were statistically significant. i.e. PHY AND RES $p< 0.05$. However the INP and INS were not significant. I.e. INP, P = 0.468, INS, 0.978. When the mediating variable was introduced in the model, the PHY variable that was initially statistically significant became insignificant $p = 0.859$ while INP factor remained statistically non-significant (INP = 0.153). Further, the RES variable that was significant remained significant at P = 0.034 however, the INS variable that was insignificant became significant at P = 0.006.

It can therefore be concluded that stakeholder involvement had a statistically significant mediating role between resource and institutional infrastructure and agricultural infrastructure. However it had no statistically significant mediating role between physical and input based infrastructure and agricultural infrastructure.

The following Figure 4.22 shows a model for the analysis stakeholder's role.

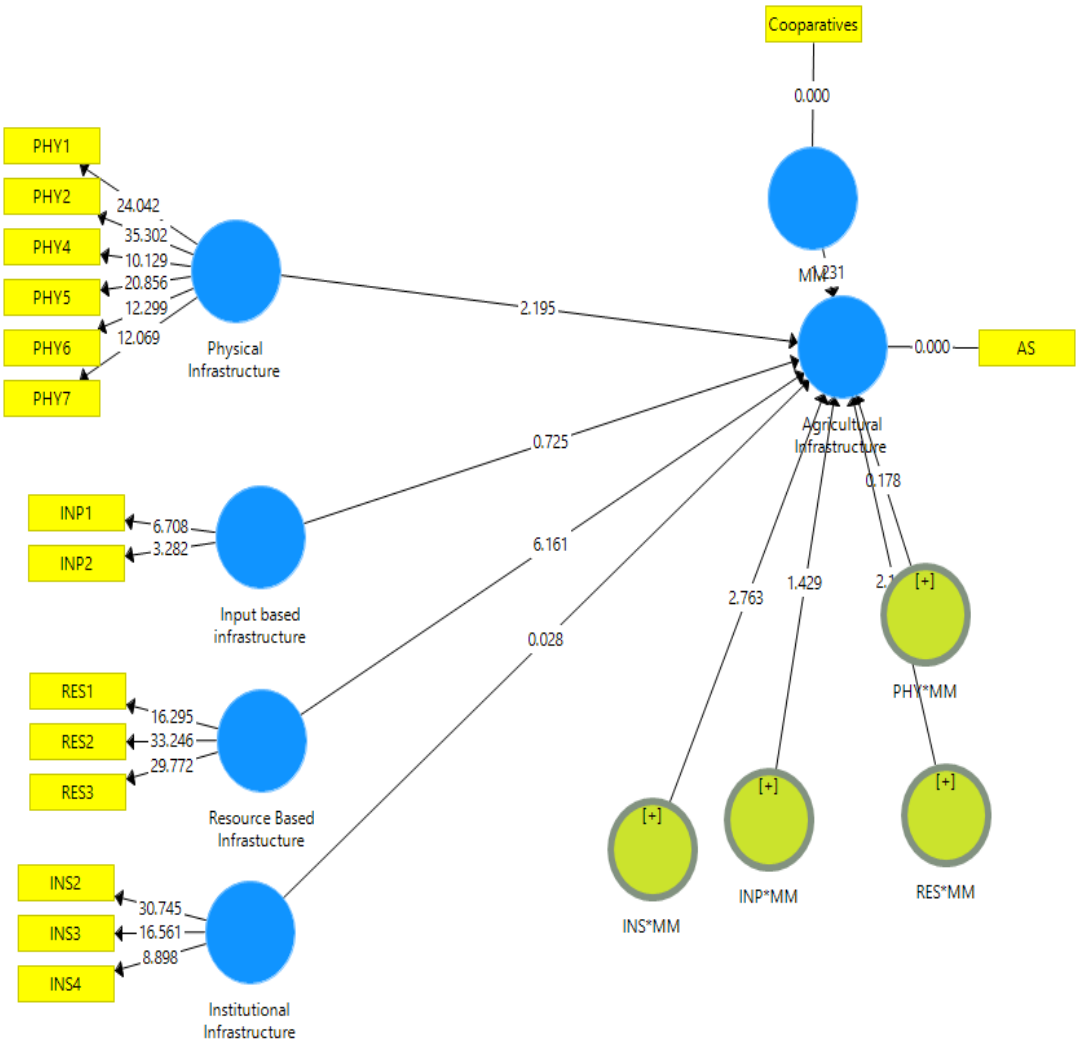


Figure 4. 24: Infrastructure Variables and Stakeholders Role

Source: Field Survey, 2021

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

The chapter gives the summary, makes conclusions and recommendations based on the findings of the study.

5.1 Summary of Findings

From the findings in chapter four, several issues raised will be discussed one by one according to the objectives of the study.

a) Demographic Profile of Respondents

The survey data shows that the majority of household's heads are men as compared to men. Crosstab analysis to establish the role of gender on agriculture infrastructure revealed that the Pearson chi-square values for the various variable constructs indicated that gender did not play a significant determinant for ownership and access for the various agriculture infrastructure which include; size of mango land, nature of acquisition of land, primary source of farmer occupation, income of farmers, additional farm training skills, technologies adopted, financing of farming activities and lastly barriers to credit access.

Majority of the respondents were between the ages of 21-50 years. The Pearson chi-square values for the various variable constructs indicated that age was a significant determinant for ownership and access for the various agriculture infrastructures which include size of mango land, nature of acquisition of land, income of farmers, training on value addition technologies, financing of farming activities. However, age was not a determinant on the primary source of farmer occupation and barriers to credit access.

On education, the findings showed that, majority had secondary education. Further, the Pearson chi-square values for the various variable constructs indicated that education was a significant determinant for ownership and access for the various agriculture infrastructures. This includes size of mango land, nature of acquisition of land, income of farmers, training on value additional technologies and age but it was not a determinant on primary source of farmer occupation financing of farming activities, barriers to credit access, and motivation for growing mangoes.

Further, the findings revealed that a high number of the respondents were married and almost half of them had a household size 1- 4 of members and 5 - 9 members. It was evident from the findings that the size of land under mango production increased with the years in mango farming and slightly half of the respondents are growing mangoes on family land.

Mango farming was the primary occupation for most of the smaller holders' farmers who earn between Kshs 5,001 - 20,000 per month. Further, the results showed that the main motivation for growing mangoes was to generate income to support their families. Apart from mango farming the small holder farmers also engage in different economic activities mainly in goat farming and poultry keeping.

b) Input Based infrastructure

The most dominant varieties of mango grown are the apple variety followed by Ngoe and Tommy respectively. The study also found out that most of the small holder farmers do not apply fertilizers to their mangoes however over half of the farmers spray mangoes twice a year using knapsack spraying equipment.

c) Resource Based Infrastructure

The results indicate that the mango farmers do not have access to electricity, irrigation facilities and dam water but the main source of water is the traditional furrows which is control by the clans.

d) Physical Infrastructure

The mode of transport that the small holder farmers utilize mostly is the motorcycle. The results also indicate that the farmers do not have access to storage facilities and agro processing plants and they do not use refrigeration services or use of preservatives to preserve mangoes. However, there are two processing plants that have been established in Tot and Cheptebo who main aim is to process the mangoes to other products like crisps and juice.

e) Institutional Infrastructure

Most of the small holder mango farmers indicated that they had undergone training on nursery management and grafting techniques. In addition, the majority of the small holder mango farmers receive agribusiness information mostly from the extension officers, farmers group and NGOs.

The mango farmer's main source of financing was their savings and key informant interviews revealed that most of the non-governmental organizations do not finance the mango farmers directly but instead they invest more in capacity building and input provision and market for the produce. In addition, almost half of the farmers cited low income and inadequate security/collaterals as the main barrier to credit access. The study also found out that the majority of the small holder mango farmers' sell their mangoes through the middlemen.

f) Agricultural infrastructure on the competitiveness of sustainable small holding mango farming.

There are numerous benefits associated with use of agricultural infrastructure for agricultural sustainability. The findings indicate majority agreed that availability of quality planting seeds has led to increased output, the availability of farm machinery enhances timely field operations, seasonal and tarmac roads can enhance the transportation of farm inputs and outputs, there has been deduction in cost of transportation from farm to market due to availability of good transport networks, cooperative societies in the area helps farmers save their income as well as giving them loans, that the availability of agricultural research facilities in the area has enhanced the quality production of mango outputs and access to agricultural extension has significantly increased adoption of modern input such as chemical fertilizer and improved seeds.

On the contrary, majority disagreed that mango farmers have proper storage that helps for securing good prices and also acts as an insurance against distress sale of produce, there is availability of cold storage that protects the perishable produce from spoilage, access of agro processing facilities that adds value to mango production, access to electricity that can pumping water for irrigation ,farmers' unions which they use to get market for farm inputs as well as getting education on quality farm inputs and financial institutions which provide loans with affordable interest during farming process.

The mango farmers also indicated that they don't get the market for their farm inputs as well as getting education on quality farm inputs through the farmers' unions further, the results indicate that most farmers don't access to loan from formal financial institutions during farming process due to unaffordable interest rates.

Results from hierarchical regression analysis to examine the contribution of agriculture infrastructure on agricultural sustainability revealed that input based infrastructure did not significantly affect agricultural sustainability as compared to physical infrastructure, resource based infrastructure and institutional based infrastructure.

g) Stake holder's involvement in Agricultural Infrastructure

The government is not providing subsidized inputs for farmers, water and electricity. County government and local institutions support farmer's unions and cooperatives through extension services, training and capacity building. The government has not invested in roads infrastructure in the region, it does not streamline mango prices nor support marketing which has led to exploitation by the middlemen who have direct links to major markets than the small holder mango farmers.

h) Dynamics in the use of Agricultural Infrastructure by Small Holder Mango Farmers

The results indicate there are a number of challenges associated with use of agricultural infrastructure which include inadequate certified and availability of quality planting seeds, high price and inadequate timely availability of fertilizers, inadequate availability and high price of pesticides ,inadequate skilled labour during peak seasons affects operations of small holders farmers, inadequate information about recommended packaging affects the marketing and prices of mangoes, high incidence of pests and diseases in mango farming which affects the output , inadequate availability of proper plant protection equipment inadequate irrigation facilities affects mango farming , the results show that there is lack access of extension services, there is inadequate availability of good grading, there was inadequate availability of agro-processing

factory**,** inadequate capital resources and collaterals as an impediment to mango farming, inadequate credit availability from institutional sources affects the operations of mango farmers, high cost of credit as another challenge that they face, inadequate marketing facilities at village level affects the marketing of the mangoes, Low price of farm produce at the time of harvesting was another factor that was cited by farmers, inadequate storage facilities was another challenge faced by mango farmers and lastly, inadequate cheap and efficient transport is another challenge experienced by mango farmers.

5.2 Conclusion

The study sought to examine agricultural infrastructure and its implication on sustainability of smallholder mango farming in Elgeyo Marakwet County, Kenya by examining the agricultural infrastructure strategies adopted to enhance sustainability of small holding ,mango farming, evaluating the stakeholder involvement in agricultural support for small holder mango farming, assessing the effects of agricultural infrastructure on sustainable mango farming and determining the challenges on the use of agricultural infrastructure sustainable small holding mango farming.

Based on the findings of the study, it can be concluded that in regard to the first objective on input infrastructure the small holder farmers use the most dominant varieties, spray their mangoes however they do not apply fertilizers. On resource based infrastructure the mango farmers do not have access to electricity, irrigation facilities and dam water but the use water from the traditional furrows. On physical infrastructure the mode of transport that the small holder farmers utilize mostly is the motorcycle. However they do not have access to storage facilities, agro processing plants and they do not use refrigeration services or use of preservatives to preserve mangoes. On

Institutional Infrastructure most of the small holder mango had undergone training on nursery management and grafting techniques, received agribusiness information mostly from the extension officers, farmers group and NGO, their main source of financing was their savings and low income and inadequate security/collaterals are the main barrier to credit access. Small holder mango farmers' sell their mangoes through the middlemen.

On objective two, the study concludes that the role of government and other stakeholders was still low on provision of subsided inputs for farmers, water and electricity, roads infrastructure, streamlining of mango prices and marketing of the mangoes. However, county government and local institutions support farmer's unions and cooperatives through extension services, training and capacity building. Further, based on structural modelling results it is concluded that government and institutional support moderated the relationship between the resource and institutional infrastructure. However it did not moderate on physical and input based infrastructure.

On objective three, it was concluded that there were numerous benefits associated with use of agricultural infrastructure for agricultural sustainability: increased output, enhanced timely field operations, enhanced the transportation of farm inputs and outputs, deduction in cost of transportation access to credit and increased adoption of modern input such as chemical fertilizer and improved seeds. Based on hierarchical regression analysis input based infrastructure did not significantly affect agricultural sustainability as compared to physical infrastructure, resource based infrastructure and institutional based infrastructure.

On objective four, there are several of challenges associated with use of agricultural infrastructure which include inadequate certified and availability of quality planting seeds, high price and inadequate timely availability of fertilizers, inadequate availability and high price of pesticides, inadequate skilled labour during peak seasons, inadequate information about recommended packaging high incidence of pests and diseases in mango farming, inadequate availability of proper plant protection equipment, inadequate irrigation facilities affects mango farming , lack access of extension services, there is inadequate availability of good grading, there was inadequate availability of agro-processing factory ,inadequate capital resources and collaterals, inadequate credit availability from institutional sources, high cost of credit, insufficient marketing facilities, Low price of farm produce at the time of harvesting, insufficient storage facilities and lastly, insufficient cheap and efficient transport. Based on the final solution for PCA, it can be concluded that the two components that accounted for about 57.98% of the variance were; insufficient certified and availability of quality planting seeds and high price and insufficient timely availability of fertilizers. This further implies that the two the major challenges experienced by small holder mango farmers in the study area.

In conclusion, in view of these findings, the study concludes that there was low use of agricultural infrastructure based on the use of different types of infrastructures. In addition, use of agricultural infrastructure is associated with several benefits but its adoption is affected by various factors and the role of government and other stakeholders in agricultural infrastructure was still low.

5.3 Recommendations

Based on the findings and conclusions derived so far, the following are the recommendations;

a) Stakeholders and specifically the county government should assist smallholder mango farmers through timely provisions of input and resource based infrastructures. From the study, small holder mango farmers are amongst the key producers and contributors to the economy and as such, development of agricultural infrastructure is very important to the sustainability and success of small holder mango farming. More emphasis should be laid on value addition of mangoes by stakeholders beginning from the grassroots levels.

b) Physical and Institutional Infrastructures development is economically and socially desirable and of the essence for the eventual industrialization of Kenya. The county and the national government should come up with approaches of handling and ensuring that the institutional and physical infrastructure, whose performance is now not to the desired expectation in Elgeyo Marakwet. In order to increase the production of high quality Mangoes, which are good for export and processing, the government should invest in road networks, irrigation systems, training, and provide markets for the mango farmers. Policy makers and planners should ensure that mango farmers are not only involved in the development process, but should be encouraged to embrace the modern technology in production of their mangoes from planting to harvesting. This is only possible if the government is able to facilitate the availability of these infrastructures.

c) The County Government should invest in resource based infrastructure and enhance provision of subsidized input based infrastructures to scale up the

adaptation of low costs innovative ideas like preservation and storage facilities. This will help in reducing post-harvest losses. Such Infrastructures facilities such as roads to enhance transport, water and electricity to increase output and enhance storage facilities.

d) There is a need for the government to control and moderate the pricing of mangoes and provide a direct link to the market to avoid farmers being exploited by the middlemen. Farmers need to be helped in coping with the challenge of the middlemen and need for necessary readjustment to enhance sustainability of small holder mango farming. Diversification of both farming and non-farm livelihood activities should be encouraged. A shift from pastoralism to mango farming which is one of the county's agricultural mainstay should be encouraged to curb the challenge of banditry and give an alternative source of livelihood; this will help in increase of income, diverse source of food , reduce poverty levels and overall resilience of households

e) Small holder farmers should form and join existing groups to enhance their access to loans and information.

f) Community members should be sensitized through training and capacity building to embrace the modern farming techniques.

g) Farmer need to be urged to take advantage of cheap information sources like mobile phones, internet, social media, to access digital agriculture and information farming problems, inputs and markets. While poor physical infrastructure has been hindering movement of agricultural extension officers, the internet is a source of valuable information for farmers

5.4 Recommendation for Further study

As a research implication, it should be noted that with the advent of Sustainable Development Goals, and other accompanying macro-level social and economic forces, there is need to further investigate agricultural infrastructure with the view to identifying the bottlenecks or constraints and factors inhibiting adoption of technological practices on mango farming and the impact of value addition on mango farming. Further research is required to explore and expose the determining factors on the growth and sustainability of small holder mango farming in attainment of Sustainable Development Goals. Such an understanding will be resourceful to agricultural Sector of Elgeyo Marakwet County, which is responsible with the handling and mobilization of small holder mango farmers at the community levels.

As a conclusive observation, small holder mango farming in Elgeyo marakwet County and Kenya has a great potential for national development and a great source of income as reflected in this study, if the current constraints or challenges of agricultural infrastructure are tackled immediately and correctly as projected herein.

REFERENCES

ABD (2011). The Mango Sub-Sector in Kenya. The Results of the Mango Tree Census and Baseline Survey for Eastern Province. Final Report. Nairobi: IDMS.

Abdul-Razak, I., Donkoh, S., & Yeboah, R. (2015). Effects of Organic Mango Out grower Scheme on Participants' Livelihood in Savelugu/Nanton Municipality, Northern Region, Ghana. *Ghana Journal of Science, Technology and Development*, 3(1), 1-14.

Abu, M., Olympio, N., Darko, J., Adu-Amankwa, P., & Dadzie, B. (2011). The Mango Industry in Ghana. *Ghana Journal of Horticulture*, 9, 136-147

Adepoju, A.A. and K.K. Salman. 2013. Increasing agricultural productivity through rural infrastructure: evidence from Oyo and Osun States, Nigeria. Int. J. Appl. Agric. Apic. Res. 9(1-2), 1-10

AGRA. (2017a). Africa Agriculture Status Report: The Business of Smallholder Agriculture in Sub-Saharan Africa (Issue 5). Nairobi, Kenya: AGRA

AGRA (2017b). AGRA Strategy and Business Plan (2017–2021*)*. Nairobi, Kenya: AGRA

AGRA (2017c). Strategy Roll-out Report 2017: Country Support and Policy Engagement. Nairobi, Kenya: AGRA.

Agricultural Business Development (ABD). (2011). The Mango Sector in Eastern Kenya: Eastern Region Mango Census and Baseline Survey. 2011. Draft Report validated at a Stakeholders' Forum in February, 2011 in Nairobi, Kenya.

Agricultural Business Development (2010). Mango Tree Census & Baseline Survey for Lower Eastern Province, Nairobi, Kenya: IEC Strategy Ltd.

Agricultural Sector Coordination Unit [ASCU]. (2011). National Food and Nutrition Security Policy. Nairobi: Government of Kenya.

Agricultural Sector Coordination Unit [ASCU]. (2012). National Agribusiness Strategy: Making Kenya's Agribusiness Sector a Competitive Driver of Growth. Nairobi: Government of Kenya.

Agwu, N., Anyanwu, I., & Kalu, H. (2015). Factors Influencing Cassava Value Addition by Rural Agribusiness Entrepreneurs in Abia State, Nigeria. *Agriculture and Rural Development,* 15 (3), Pp 19–24

Ahlerup, P, Olsson, O, &Yanagizawa, D. (2009). Social Capital Vs. Institutions in the Growth Process. *European Journal of Political Economy*, Vol. 25, No.1, pp. 1-14. Ahmed, A., Alam, M., Momin, M., Rahman, R., Alam, K., Islam, A., & Ali, Md. (2017). Production Performance of Mango in Dinajpur District Of Bangladesh: A Case Study At Sadar Upazilla. *European Journal of Agriculture and Forestry Research*, 5, 16 - 57

Alexandratos, N. and Bruinsma, J. (2012). World Agriculture Towards 2030/2050. ESA Working Paper No. 12-03. Rome: FAO

Ali, D. A., Deininger, Klaus D, and Goldstein,M (2014). Environmental and Gender Impacts Of Land Tenure Regularization in Africa: Pilot Evidence from Rwanda. *Journal of Development Economics,* Volume 110, 2014,

Altieri, M.A. and Koohafkan, P. (2008). Enduring Farms: Climate Change, Smallholders and Traditional Farming Communities. *Environment and Development Series, 6*. Penang, Malaysia: Third World Network.

Amaza, P., Abdoulaye, T., Kwaghe, P. And Tegbaru, A. (2009). Changes in Household Food Security and Poverty Status in the PROSAB Area of Southern Borno State, Nigeria. *International Institute of Tropical Agriculture (IITA) Promoting Sustainable Agriculture in Borno State (PROSAB)*. IITA, Nigeria, 2009.

Anderson, K. and W.A. Masters. (2007). Distortions to agricultural incentives in Africa. Agricultural Distortions, Working paper 56. The World Bank, Washington. Doi: 10.1596/978-0-8213-7652-2

Andrea, C. (2012). Understanding the Marketing Chain of Mango and Grapes in the Sao Francisco Valley. São Francisco: Universidade.

Arias, P., Hallam, D., Krivonos, E. and Morrison, J. (2013). Smallholder Integration in Changing Food Markets. Rome: Food and Agriculture Organization of the United Nations. Asher, S & Novosad, P. (2020). Rural Roads and Local Economic Development. *American Economic Review*, 110. 797-823

Atamanov, A., Azevedo, J., Aguilar, R., Chen, S., Rodas, P., Dewina, R. (2018). April 2018 PovcalNet Update: What's New? *Global Poverty Monitoring Technical Note Series*, Issue 1, 4, 2018. http://documents.worldbank.org/curated/en/173171524715215230/April-2018-Povcalnet-Update-What-s-New

Ayele, S. and Bosire, C. (2011). Farmers' Use of Improved Agricultural Inputs and Practices: Review and Synthesis of Research in Ethiopia. Nairobi, Kenya: ILRI.

Berhane, G., Ragasa, C., Abate, G., & Assefa, T. (2018). The State of Agricultural Extension Services in Ethiopia and their Contribution to Agricultural Productivity. *ESSP Working Paper 118*. Washington, DC: International Food Policy Research Institute (IFPRI).

Berhanu, G and Moti, J (2010). Commercialisation of Small Holder: Is Market Participation Enough? AAE Third Conference / AEASA 48th Conference, September 19 - 23, 2010, Cape Town, South Africa. No. 96159. Africa Association of Agricultural Economists (AAAE) and Agricultural Economists Association of South Africa (AEASA).

Besley, T. and Burgess, R. (2003), "Halving Global Poverty", *Journal of Economic Perspectives*, Volume 17, 3, 3- 22.

Bhattacharya, A., Meltzer, J., Oppenheim, J., Qureshi, Z., & Stern, N. (2016). Delivering on Sustainable Infrastructure for Better Development and Better Climate. Washington DC: The Brookings Institute.

Baba, S., Mir, S., Khan, A., Bazaz, N., & Manzoor, M. (2015). Rural Infrastructure and Agricultural Growth Linkages in Jammu and Kashmir. *Economic Affairs*, *60*(1), 143.

Bartholomew, D. (2010). Principal Components Analysis. In International Encyclopedia of Education (Third Edition), Peterson, P., Baker, E. and McGaw, B. (Eds.). Amsterdam: Elsevier, pp. 374-377

Brunello G. (2004). Labour Market Institutions and the Complementarity between Education and Training In Europe. Education, Training and Labour Market Outcomes in Europe, Checchi D., Lucifora C. (Eds), Palgrave, Pp. 188 – 209.

Buckingham, S. & Turner, M. (Eds.). (2008). Understanding Environmental Issues. London*:* Sage Publications Ltd.

Carlisle, L. (2016). Factors Influencing Farmer Adoption of Soil Health Practices in the United States: A Narrative Review. *Agroecology and Sustainable Food Systems***,** 2016, 40, 583–613.

Cattell, R. and Jaspers, J. (1967) A General Plasmode for Factor Analytic Exercises and Research. *Multivariate Behavioral Research Monographs*, No. 30-10-5-2

Cattell, R. (1966). The Scree Plot Test for the Number of Factors. *Multivariate Behavioral Research*, 1, 140-161

Chengappa, P. (2018). Development of Agriculture Value Chains as a Strategy for Enhancing Farmers' Income. *Agricultural Economics Research Review*, *30*(347-2018-3185), 1-12.

Coakes S. (2005). SPSS: Analysis without Anguish: Version 12.0 for Windows. Queensland, Australia: Wiley

DAFF (2017). Economic review of the South African agriculture. URL: URL: http://www.daff.gov.za/Daffweb3/PortaW0/Statistics%20and%20Economic%20Anal ysis/Economic%20Analysis/Eco-nomic%20Review%202016.pdf (accessed 2 May 2017).

Da Silva, Jo., Kernaghan, S & Luque, A. (2012): A Systems Approach To Meeting The Challenges of Urban Climate Change. *International Journal of Urban Sustainable Development,* Vol.4, pp.125-145

Deshingkar, P. (2005), "Maximising the Benefits of Internal Migration for Development", keynote paper commissioned for the Regional Conference on Migration and Development in Asia, Lanzhou, China, 14-16 March.

Deshingkar, P. and D. Start (2003). "Seasonal Migration for Livelihoods, Coping, Accumulation and Exclusion", Working Paper 220, Overseas Development Institute, London.

Dhenge, S. (2018). Constraints Faced By the Commercial Mango Growers in Efficient Management of Mango Orchard. *International Journal of Chemical Studies*, 2018, 6 (5), pp. 982-984

Donaldson, D. (2018). Railroads of the Raj: Estimating the Impact of Transportation Infrastructure. *American Economic Review*, *108*(4-5), 899-934.

Donkor, E., Onakuse, S., Bogue, J., & de los Rios Carmenado, I. (2018). Promoting value addition among farmers in the cassava food value chain in Nigeria. *British Food Journal*, 120 (9), pp2047-2065.

Dong, Y and Peng, C. (2013). Principled Missing Data Methods for Researchers. *SpringerPlus*, 2013, 2, pp. 222.

Du, L., Pinga, V., Klein, A., & Danton, H. (2015). Leveraging Agriculture for Nutrition Impact Through the Feed the Future Initiative. *Advances in Food and Nutrition Research*, Vol. 74, pp. 1- 46). Academic Press

Duncan, B. & Brants, C. (2004). Access to and Control Over Land from a Gender Perspective: A Study Conducted in the Volta Region of Ghana. Rome: FAO

Eghan, D. (2017). Access to Export Market for Mango Farmers in the Manya District of Ghana. *Journal of Economics and Sustainable Development*, 8(12), 2222-2855

Eke,I.C. and J.A.L. Effiong. 2016. The effects of capital accumulation on crop production output in Nigeria. Int. J. Agric. Earth. Sci. 2(3), 62-81. URL: https://iiardpub.org/get/IJAES/VOL.%20 2%20NO.%203%202016/THE%20EFFECTS.pdf (accessed 14 September 2018).

Emongor, V (2015). The Effects of Temperature on Storage Life of Mango (*Mangifera Indica* L.). *American Journal of Experimental Agriculture* 5(3): 252-261.

Fakayode, B.S., O.A. Omotesho, A.B. Tsoho, and P.D. Ajayi. 2008. An economic survey of rural Infrastructures and agricultural productivity profiles in Nigeria. *Eur. J. Soc. Sc.* 7(2), 158-171.

Farnworth, R., Baudron, F., Andersson, Jens, Misiko, M., Badstue, L & Stirling, C. (2016).

Gender and Conservation Agriculture in East and Southern Africa: Towards A Research Agenda. *International Journal of Agricultural Sustainability*, 14, pp. 142–165.

FAO (Food and Agriculture Organization) of the United Nations (2005). Value Chain Analysis: A Case Study of Mangoes in Kenya. Washington DC: World Bank Publication.

FAO (Food and Agriculture Organization) of the United Nations (2007). The Food and Agriculture Organization database (FAOSTAT). Rome: FAO

FAO (Food and Agriculture Organization) of the United Nations (2009). Increasing Incomes and Food Security of Small Farmers in West and Central Africa through Export of Organic And Fair Trade of Tropical Fruit. Rome: FAO

FAO (2011). Save and Grow: A Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production. Rome: FAO

FAO (2011). Save and Grow: A Policymaker's Guide to the Sustainable Intensification of Smallholder Crop Production. Rome: FAO

FAO (2012). Towards the Future We Want: End Hunger and Make the Transition to Sustainable Agricultural and Food Systems. Rome: Food and Agriculture Organization of the United Nations.

FAO. (2014). Value Chain Analysis: A Case Study of Mangoes in Kenya. Prepared by the *Sugar and Beverages Group Raw Materials, Tropical and Horticultural Products Service Commodities and Trade Division.* Web link entered in June 2014. Https: / / www. Responsibleagroinvestment.org / sites / responsibleagroinvestment.org/ files / Mango_FAO_ Value_chain_Analysis_Kenya_Case.pdf).

FAO (2014). Youth and Agriculture: Key challenges and concrete solutions Published by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Technical Centre for Agricultural and Rural Cooperation (CTA) and the International Fund for Agricultural Development (IFAD). FAO

FAO (2014). The State of Food and Agriculture 2014: Innovation in Family Farming. Rome: FAO

FAO, WFP, IFAD (2012). The State Of Food Insecurity in the World, 2012: Economic Growth Is Necessary But Not Sufficient To Accelerate Reduction Of Hunger. Rome: FAO

FAO, IFAD and WFP. (2013). The State Of Food Insecurity In The World 2013. The Multiple Dimensions of Food Security. Rome: FAO.

Faraday, A and Plummer, K (2005). Doing Life Stories, in: R Miller (ed.)., Biographical Research Methods. London: Sage Publications

Ferreira, T. (2015). Does education enhance productivity in smallholder agriculture? Causal evidence from Malawi. Stellenbosch working paper series no. WP05/2018. URL: URL:https://resep.sun.ac.za/does-education-enhance-productivity-in-smallholder- agriculture-causal-evidence-from-malawi/ (accessed 11 June 2019).

Fischer, E. and Qaim, M. (2012). Linking Smallholders to Markets: Determinants and Impacts of Farmer Collective Action in Kenya. *World Development,* Vol. 40, No. 6, pp. 1255–1268

Gajigo, O. and Lukoma, A. (2011) Infrastructure and Agricultural Productivity in Africa, AfDB.

Ganeshamurthy, A. (2019). Enhancing Mango Productivity through Sustainable Resource Management. *Journal of Horticultural Science*, 13(1), 2018

Garson, D. (2015). Structural Equation Modeling: 2015 Edition. North Carolina: Statistical Associates Publishers

Gathambiri, C., Gitonga, J., Kamau, M., Njuguna, J., Kiiru, S., Muchui, M., Gatambia, E, and Muchira, D. (2009). Assessment of Potential and Limitation of Postharvest Value Addition of Mango Fruits in Eastern Province: A Case Study in Mbeere and Embu Districts. Transport Information Service (TIS) from the German Insurance Association (GDV e.V.)

Gathee, J. (1991). Challenges Facing the Kenyan Horticultural Producer for Export. *Acta Hort* (270), 271-278.

Gashaw, B. A., Habteyesus, D. G., & Nedjo, Z. S. (2018). Determinants of coffee value addition by smallholder farmers in Jimma Zone, Ethiopia. *The International Journal of Business Management and Technology*, 2 (8), pp2–13

Genius, M.; Koundouri, P.; Nauges, C.; Tzouvelekas, V. (2014). Information Transmission in Irrigation Technology Adoption and Diffusion: Social Learning, Extension Services, and Spatial Effects. *American Journal of Agricultural Economics,* 2014, 96, 328–344.

Gholami, R, Sulaiman, A., Ramayah, T., and Molla, A. (2013). Senior Managers' Perception On Green Information Systems (IS) Adoption and Environmental Performance:
Results From A Field Survey. *Information & Management*, 50, pp. 431–438.

Gitonga, J., Gathambiri, C., Kamau, M., Njuguna, K., Muchui, M., Gatambia, E., and Kiiru, S. (2014). Enhancing Small-Scale Farmers' Income in Mango Production through Agro-Processing and Improved Access to Markets. *Proceedings of 10th KARI Biennial Conference, 2014*

Griesbach, J. (2003). Mango growing in Kenya. Nairobi: ICRAF

Gosh, N. (2004). Sustainable Ways of Soil Fertilization: Farmers' Practices in India. *ISEE Conference Paper*, Volume 49, Issue 2, 2004, Montreal

Gosh, N. (2013). Impact of Emerging Marketing Channels in Agricultural Marketing-Benefit to Producer-Seller and Marketing Costs and Margins of Agricultural Commodities. Delhi: Nilabja Ghosh Institute of Economic Growth Delhi

Goyol, S., & Pathirage, C. (2017). Impacts of Climate Change on Agrarian Infrastructure and Cascading Effects on Human and Economic Sustainability in Nigeria. *International Conference on Climate Change and Sustainable Development in Africa (ICCCSDA*), Sunyani, Ghana, Jan. 2017

Graeub, B., Chappell, J, Wittman, H., Ledermann, S., Kerr, R., and Gemmill-Herren, B. (2015). The State of Family Farms in the World. *World Development*, Volume 87,2016, pp. 1-15

Grammatikopoulou, I., Pouta, E., and Myyrä, S. (2015). Exploring the Determinants for Adopting Water Conservation Measures. What Is The Tendency Of Landowners When The Resource Is Already At Risk? *Journal of Environmental Planning and Management*. 2015, 1–22.

Griesbach J. (2003). Mango Growing in Kenya. Nairobi: ICRAF

Gudergan, S., Ringle, M., Wende, S., and Will, A. (2008). Confirmatory Tetrad Analysis in PLS Path Modeling. *Journal of Business Research*, 61(12): 1238-1249.

Gwandu, T., Mtambanengwe, F., Mapfumo, P., Mashavave, T. C., Chikowo, R., and Nezomba, H. (2014). Factors Influencing Access to Integrated Soil Fertility Management Information and Knowledge and Its Uptake among Smallholder Farmers in Zimbabwe. *The Journal of Agricultural Education and Extension*, *20*(1), 79–93.

Hair, J., Black, C., Babin, J., & Anderson, R. (2010). Multivariate Data Analysis. Seventh Edition. Upper Saddle River, New Jersey: Prentice Hall

Hajir, J., Obeidat, B., Al-dalahmeh, M & Masa'deh, R. (2015). The Role of Knowledge `Management Infrastructure in Enhancing Innovation at Mobile Telecommunication Companies in Jordan. *European Journal of Social Sciences*, Vol. 50, No. 3 December, 2015, pp.313-330 http://www.europeanjournalofsocialsciences.com/

Hartono, D., Irawan, T., and Irawan, F. (2010). Infrastructure Improvement and Its Impact on Indonesian Economic Performance. Electronic document. Retrieved from http://lp3e.fe.unpad.ac.id/wopeds/201008.pdf. Accessed 5 January 2013.

Hartoyo, S. (2013). The Impact of Rural Road Rehabilitation on Rice Productivity and Farmers Income in Kemang Village, Cianjur, West Java, Indonesia. *J. ISSAAS*. Vol, 19, No.2:18-29.

Hayes, J. (2012). Modeling and Remodeling Writing. *Sage Journals,* Vol. 29, Issue: 3, pp. 369-388 Help Age International Tanzania (2015). Learning with older people about their transport and mobility problems in rural Tanzania. Final Report. AfCAP Project TAN2015D. Africa Community Access Partnership (AfCAP), Thame,UK.76p.Availableat: http://www.afcap.org/SitePages/Rural%20access%20library.aspx

Henseler, J., Ringle, C. & Sarstedt, M. (2015). A New Criterion for Assessing Discriminant Validity in Variance-based Structural Equation Modeling. *Journal of the Academy of Marketing Science,* 43. 115-135. 10.1007/s11747-014-0403-8.

Hesselberg, J. (2017). How Can Poverty Be Reduced Among Small-Scale Farmers In The Highlands of Western Cameroon? *Ghana Journal of Geography. ISSN* 0855-9414. *9*(1), s 42- 66

Horticultural Crops Development Authority (HCDA) (2010). Baseline Survey and Census of Mango Trees in Eastern Province. Nairobi: Government of Kenya.

HCDA. (2008b). Horticulture Data 2005-2007 Validation Report. Nairobi: National Horticulture Market Information System Secretariat

HCDA Borasoft Team. (2014). National Horticulture Market Information System Baseline Survey Report. Nairobi: National Horticulture Market Information System Secretariat

HCDA (2014). National Horticulture Validated Report 2014. Nairobi: Ministry of Agriculture, HCDA

Hussein S, and Yimer Z (2013). Assessment of Production Potentials and Constraints of Mango (*Mangifera indica L.*) At Bati, Oromia Zone, Ethiopia. *International Journal of Sciences: Basic and Applied Research* 11(1):1-9.

ICARDA. (2010). ICARDA Annual Report. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas.

ICARDA. (2011). ICARDA Annual Report. Aleppo, Syria. : International Center for Agricultural Research in the Dry Areas.

Idrisa Y., Ogunbameru, O., Madukwe, C. (2014): Logit and Tobit Analyses of the Determinants Of Likelihood of Adoption and Extent of Adoption of Improved Soybean Seed in Borno State, Nigeria. *Greener Journal of Agricultural Sciences*, 2: 37 – 45.

IFAD. (2011). Rural Poverty Report 2011. New Realities, New Challenges: New Opportunities For Tomorrow's Generation. Rome: IFAD

IFAD. (2013). African Agricultural Development: Opportunities and Challenges. Statement by IFAD President at the *6th Africa Agriculture Science Week and FARA General Assembly,* 2013). http://www.ifad.org/events/op/2013/fara.html

International Fund for Agricultural Development (IFAD) (2013). Smallholders, Food Security, and the Environment Enabling Poor Rural People to Overcome Poverty. FAO Factsheet: www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDERS.pdf

IFPRI (2019). Achieving Agricultural Sustainability Depends on Gender Equality. Washington, DC: IFPRI

Isakson, S. (2014). Food and Finance: The Financial Transformation of Agro-Food Supply Chains. *Journal of Peasant Studies*, *41*(5), 749-775.

Iyangbe, C and Orewa, S. (2009). Determinants of Daily Protein Intake among Rural and Low-Income Urban Households in Nigeria. *American European Journal of Scientific Research*, Vol. 4, pp.290-301, 2009

Jawale S, and Ghulghule, N.(2015). Constraints and Suggestions of Kesar Mango Production in the Export Zone of Marathwada Region. *International Journal of Commerce, Business and Management*, 2015, 4(5):713-72

Jayne T.S. and Muyanga Milu (2006) *Agricultural Extension by farmer groups in Kenya: Practice and Policy Lessons*. Egerton University, Nairobi, Kenya. 2006.

Jessop, Diallo, Duursma et al. (2012) "Creating Access to Agricultural Finance Based on a horizontal study of Cambodia, Mali, Senegal, Tanzania, Thailand and Tunisia" The A Savoir 14,23-24..

Jha, A., Kickbusch, I., Taylor, P., & Abbasi, K. (2016). Accelerating Achievement of the Sustainable Development Goals. *British Medical Journal*, 352, Pp1-2

Jibowo, A. (2000): Essentials of Rural Sociology (2nd Ed.). Abeokuta: Gbemi Sodipo Press Ltd

Jiri, O., Mafongoya, P., Mubaya, C., Mafongoya, O. (2016). Seasonal Climate Prediction and Adaptation Using Indigenous Knowledge Systems in Agriculture Systems in Southern

KDB (2016). Report of a Study on Assessing the Cost of Production Structures in Dairy Systems in Kenya. Nairobi: Government Printers

Kemtsop G A and Starkey P (2013). Rural transport service indicators: report of the Pitoa– Djallou Road, Northern Cameroon. June 2013. International Forum for Rural Transport and Development (IFRTD) Project AFCAP GEN/060. London. African Community Access Programme (AFCAP). 27p. Available at: http://www.ruraltransport.info/RTSi/resources/ project_outputs.php

Kehlenbeck, K., Rohde, E., Njuguna, J., Jamnadass, R. (2012) Mango: Cultivation in Different Countries. In: Sudha, V., Rajmohan, K., Govil, J., Peter, V., and Thottappilly, G., (Eds.) *Mango Production in Kenya, Vol. 2*. Houston, TX: Studium Press LLC; p. 186–207.

Kennedy, N. O. (2015). Adoption of value-addition technologies among mango fruit farmers in Machakos county. Kibabii University 1st International Conference Proceedings; June 22-24, 2015.

Kenya Financial Sector Deepening (FSD) (2015): Opportunities for Financing the Mango Value Chain: A Case Study of Lower Eastern Kenya. Nairobi, Kenya: FSD Kenya.

Khapayi, M. and Celliers, P. (2016). Factors Limiting and Preventing Emerging Farmers To Progress to Commercial Agricultural Farming in the King William's Town Area of The Eastern Cape Province, South Africa. *South African Journal of Agricultural Extension,* 2016, 44, 25–41

Kipkorir, D., & Kareithi, J.N. (2012). Human and Natural Factors in the Deterioration of Indigenous Irrigation Furrows in Marakwet, Kenya.

Kiprono, P. & Matsumoto, T. (2014). Roads and Farming: The Effect of Infrastructure Improvement on Agricultural Input Use, Farm Productivity and Market Participation in Kenya. Paper Presented at 'Economic Development in Africa' held at The University of Oxford. *Agricultural Economics Research, Policy and Practice in Southern Africa,* Volume 57, 2018, Issue 3-4.

Kruger, E and Gilles, J. (2014). Review of Participatory Agricultural Research and Development In South Africa and Kwazulu-Natal. Available online: http://Www.Mahlathini.Org/WpContent/Uploads/2016/11/Participatory-Agricultural-Research-In-Sa_Final_-12-June-2014.

Kolawole, D., Wolski, P., Ngwenya, B., Mmopelwa, G. (2014). Ethno-Meteorology and Scientific Weather Forecasting: Small Farmers and Scientists' Perspectives on Climate Variability in the Okavango Delta, Botswana. *Climate Risk Management,* 2014, 4, 43–58.

Koohafkan, P. (2011). Globally Important Agricultural Heritage Systems. Presentation at the International Forum on Globally Important Agricultural Heritage Systems (GIAHS), Beijing, 9-12 June 2011. Rome: FAO

Kumar, V., K.G. Wankhede, and H.C. Gena. 2015. Role of cooperatives in improving livelihood of farmers on sustainable basis. *Am. Educ. Res. J.* 3(10), 1258-1266. Doi: 10.12691/education-3-10-8

Kyomugisha, H., Sebatta, C., & Mugisha, J. (2018). Potato Market Access, Marketing Efficiency and On-Farm Value Addition in Uganda. *Scientific African,* pp 13-25.

Larsen, K., Kim, R. and Theus, F. (Eds.). (2009). Agribusiness and Innovation Systems in Africa. A publication sponsored by the *World Bank Institute and Agriculture and Rural Development.* Washington, DC: World Bank

Leake, G, Bereket., G, Tedros, G, and Fikremariam, B. (2015). Apple Mango Value Chain In Northern Ethiopia: Case Study Of Mereb-Leke District. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*, 14(3): 16-21.

Leake, W. (2018). Factors Influencing Application of Fertilizer by Smallholder Farmers of Northern Ethiopia. *Journal of Economics and Sustainable Development*, Vol.6, No.3, 201

Llanto, Gilberto M., 2012. The Impact of Infrastructure on Agricultural Productivity. *Discussion Papers 2012 – 12.* Philippine Institute of Development Studies.

Leichenko, R. & O'Brien, K. (2008). Environmental Change and Globalization: Double Exposures. New York: Oxford University Press

Lowder, S., Skoet, J and Singh, S. (2014). What Do We Really Know About the Number Of Farms in the World? *ESA Working Paper No.* 14-02. Rome, Agricultural Development Economics Division, FAO.

Macharia, Peter. Kenya National Report. (29 July 2004). Gateway to Land and Water Information. Retrieved 21 April 2008, from http://www.fao.org.

Maitima M J, Rakotoarisoa A M, and Kang'ethe K E (2010) Responding to changing Markets in a context of increased competition for resources. In:Livestock in a Changing landscape, Volume 2. Experiences and regional perspectives. Editors: Gerber P, Mooney A H, Dijkman J, Tarawali S and De Haan C.Island press, Washington, DC.

Manda, J, Alene, D., Gardebroek, C, Kassie, M, and Tembo, G. (2016). Adoption and Impacts of Sustainable Agricultural Practices on Maize Yields and Incomes: Evidence from Rural Zambia. *Journal of Agricultural Economics*, 67 (1): 130–153. doi: 10.1111/1477-9552.12127.

Mangisoni, J. (2006). Markets, Institutions and Agricultural Performance in Africa. *ATPS Special Paper Series*, No. 27, Nairobi: The African Technology Policy Studies (ATPS) Network.

Mbanaso, E., Agwu E., Anyanwu, C., Asumugha, N. (2012): Assessment of the Extent of Adoption of Sweet Potato Production Technology by Farmers in the Southeast Agro Ecological Zone of Nigeria. *Journal of Agriculture and Social Research*, 12: 124 – 136.

Ministry of Agriculture (2005).Value Chain Analysis of Mango Sub-sector by Agri-systems (E.A) Ltd, Kenya. Nairobi: Government of Kenya

Ministry of Agriculture. (2010a). National Horticulture Policy. Nairobi: Government of Kenya.

Ministry of Agriculture. (2010b). Agricultural Sector Development Strategy (ASDA).Nairobi: Government of Kenya

Ministry of Food and Agriculture (MoFA) (2011). Youth in Agriculture: Programme Policy, Strategy and Sustainability. Available online at: www.mofa.gov.gh. Accessed on 24th August, 2014.

Mirjat, M., Jiskani, M., Siyal, A., and Mirjat, M. (2011). Mango Production and Fruit Quality Under Properly Managed Drip Irrigation System. *Pakistan Journal of Agriculture Agricultural Engineering and Veterinary Sciences,* 27(1):1-12.

Mkonda, Y., & He, X. (2017). Yields of the Major Food Crops: Implications to Food Security And Policy in Tanzania's Semi-Arid Agro-Ecological Zone. *Sustainability*, 9(8), Pp1490

MoFA, (2015). Agriculture in Ghana – Facts and Figures (2014). Statistics, Research and Information Directorate (SRID). Washington DC: Word Bank

Mohammad, T., Achem, A and Abdulquadri, F. (2014): Factors Influencing Adoption Of Agricultural Processing Technologies Developed By National Centre for Agricultural Mechanization (NCAM) In Ifelodun Local Government Area, Ilorin Kwara State. *International Journal of Science and Research*, 3: 413 – 417

Mujuka E, Mburu J, Ogutu A, Ambuko J. (2020) Returns to Investment in Postharvest Loss Reduction Technologies among Mango Farmers in Embu County, Kenya. *Food Energy Security.* 2020; 9:e195. https ://doi.org/10.1002/fes3.195

Muhie, Seid & Yimer, Zeru. (2013). Assessment of Production Potentials and Constraints of Mango (Mangifera INDICA) At Bati, Oromia Zone, Ethiopia. *International Journal of Sciences: Basic and Applied Research* (IJSBAR), Vol. 11, 1-9.

Muok B, Kimondo J, and Atsushi I (2011) Farmer to farmer extension; experience in dry lands Kenya. Publication of Forest Extension. International union of forestry research organizations

Musinga M, Owuor A, Njuguna J, Gachanja G. (2012). The mango value chain in Kenya. Nairobi.

Musyoka, K & Isaboke, H. (2020). Farm-Level Value Addition among Small-scale Mango Farmers in Machakos County, Kenya. *Journal of Agricultural Extension*. 24. 85-97. 10.4314/jae.v24i3.8.

Mututo, D. (2011). Mango Farming Changing Livelihood of Farmers in Makueni County. Department of Information and Public communications. Kenya.

Mwanda, C.O. Engineering Division, Ministry of Agriculture. (2010). A note on weed control in Machakos District, Kenya.

Naamwintome, B., & Bagson, E. (2013). Youth in Agriculture: Prospects and Challenges in The Sissala Area of Ghana. *Net Journal of Agricultural Science*, 1(2), 60-68

Nagayets, O. (2005). Small Farms: Current Status and Key Trends. Paper prepared for the *Future of Small Farms Research Workshop.* Wye College, June 26–29, 2005.

Ndege, N. (2015). Access and Use of Knowledge on Fruit Processing Technologies by Smallholder Farmers: A Case Study of Mwala, Machakos County (Masters Thesis), University Of Nairobi, Kenya. Pp1-64

Njenga P, Opiyo R and Starkey P (2013). Rural transport service indicators: Report of the Gitugi-Kiamara Junction Road, Murang'a County, Kenya. June 2013. International Forum for Rural Transport and Development (IFRTD) Project AFCAP GEN/060. London. African Community Access Programme (AFCAP). 24p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

Nyangena, W, & Sterner, T (2008). Social Capital and Institutions in Rural Kenya: Is Machakos Unique? *Environment for Development Discussion Paper Series* Available from:<http://www.efdinitiative.org/publications/social-capital-and-institutions-rural-kenya-machakos-unique> [9 July 2015].

Niyibigira, E.I., Lada, V.Y. and Abdullay, Z.S. (2003). Mango production and marketing in Zanzibar: potential, issues and constraints. Acta Hort. (ISHS) , 621, 89-93.

Ntale, J., Anampiu, R., & Gathaiya, C. (2015). Agro-Entrepreneurship Readiness Model: An Empirical Investigation in Kenya. *International Journal of Development and Sustainability,* 4(7), Pp825-839.

Nzomo J., Byaruhanga, J., Maritim, K. and Omboto P. (2007). Determinants of Technology Adoption in the Production of Horticultural Export Produce in Kenya. *African Journal of Business Management.*1:129 –135.

Obidike, Nnenna. (2011). Rural Farmers' Problems Accessing Agricultural Information: A Case Study of Nsukka Local Government Area of Enugu State, Nigeria. 2011.

Oduro-Ofori, E., A.P. Aboagye, and N.A.E. Acquaye. (2014). Effects of education on the agricultural productivity of farmers in the Offinso Municipality. Int. J. Dev. Res.4(9),1951-1960.URL:URL: https://www.journalijdr.com/sites/default/files/issue- pdf/1839.pdf (accessed 06 June 2020).

Okorley, E., Acheampong, L., & Abenor, M. (2014). The Current Status of Mango Farming Business in Ghana: A Case Study of Mango Farming in the Dangme West District. *Ghana Journal of Agricultural Science,* 47(1), 73-80

Okoth, M., Sila, N., Onyango, A., Owino, O., Musembi, M., and Mathooko, M. (2013). Evaluation of Physical and Sensory Quality Attributes of three Mango Varieties at Three Stages of Ripeness, Grown in Lower Eastern Province of Kenya. 2013. V. 17.2608-2618.

Opara, U. (2010). Personal and Socio-Economic Determinants of Agricultural Information Use By Farmers in the Agricultural Development Programme (ADP) Zones of Imo State, Nigeria. Library Philosophy and Practice (e-journal). 434.

Oyewole, M., & Eforuoku, F. (2019). Value Addition on Cassava Wastes among Processors in Oyo State, Nigeria. *Journal of Agricultural Extension*, 23(3), Pp 135-146.

Pallant, J. (2011) SPSS Survival Manual: A Step By Step Guide to Data Analysis Using the SPSS Program (4th Edition). Berkshire: Allen & Unwin.

Patel, A. (2014). Infrastructure for Agriculture & Rural Development in India Need fora Comprehensive Program & Adequate Investment. *Microfinance Gateway*, 1, 13, 2010,

Perez, C., Jones, E., Kristjanson, P., Cramer, L., Thornton, P., Forch, W., & Barahona, C. (2015). How Resilient Are Farming Households and Communities to a Changing Climate In Africa? A Gender-Based Perspective. *Global Environmental Change*, 34 (September), 95–107. Retrieved April 24, 2016, from http://doi.org/10.1016/j.gloenvcha.2015.06.003

Peterman, A., Behrman, J., Quisumbing, A., (2014b). A Review of Empirical Evidence On Gender Differences in Non-land Agricultural Inputs, Technology, and Services in Developing Countries. *Gender in Agriculture*. Springer, pp. 145–186.

Peyton, F. (2019). Reshaping Africa's Rural Food Systems and Cutting Food Losses. Ensia. Mountain View, CA: Creative Commons

Pinto, J., Slevin, D. & English, B. (2009). Trust in Projects: An Empirical Assessment of Owner/Contractor Relationships. *International Journal of Project Management,* 27, pp. 638-648

Poulton, C, Frankenberger, T & Ajay, O (2014) African Agriculture: Drivers of Success for CAADP Implementation: Synthesis Report. London: Firetail

Quisumbing, A., & Pandolfelli, L. (2010). Promising Approaches to Address the Need of Poor Female Farmers: Resources, Constraints, and Interventions. *World Development*, 38(4), 581–592

Raisuddin A. and M. Hossain. (1990). Developmental Impact of Rural Infrastructure in Bangladesh. Research Report. Bangladesh: International Food Policy Research Institute.

Ramakrishnan P.S. and Kumar, A. (2010). Energy Flow through an Apatani Village Ecosystem of Arunachal Pradesh in Northeast India. *Human Ecology*, Vol. 18, No. 13.

Ramessur, A., and Ranghoo-Sanmukhiya, V. (2011). RAPD Marker-Assisted Identification of Genetic Diversity among Mango (*Mangifera indica*) Varieties in Mauritius. *International Journal of Agriculture and Biology*, Vol. 13, pp.167–173.

Regasa, D., Afework, H., Bekele, A., & Dawit, A. (2019). Determinants of Mango Market Supply by Smallholder Farmers (Study in Assosa Zone of Benishangul Gumuz Region: An Outcomes from Mango Producers in Ethiopia). *International Journal of Agriculture & Agribusiness* ISSN: 2391-3991, Volume 3 Issue 2, page 136 – 149.

Regasa, G., Negash, R. Eneyew, A., and Bane, D. (2019). Determinants of Smallholder Fruit Commercialization: Evidence from Southwest Ethiopia. *Review of Agricultural and Applied Economics: Acta Oeconomica et Informatica*, Number 2, 2019 pp. 96-105

Rehman, K., Rehman, Z., Naveed, S., Khan, A., Allah, N and Shafiq, R. (2013). Impacts of Job Satisfaction on Organizational Commitment: A Theoretical Model for Academicians in HEI of Developing Countries like Pakistan. *International Journal of Academic Research in Accounting, Finance and Management Sciences*, Vol. 3 (1), pp. 80–89

Richardson K., Nkalu, N., Idenyi, J., Arazu, W. (2020). Infrastructural Development: Sustainable Agricultural Output and Employment in ECOWAS Countries. *Sustainable Futures* (2020). doi: https://doi.org/10.1016/j.sftr.2020.100010

Ringle, C., Wende, S., & Will, A. (2005). SmartPLS 2.0 (Beta). Hamburg, (www.smartpls.de)

Rosario, R., & Potts, J. (2016). A Study on Entrepreneurial Attitudes of Upcountry Vegetable Farmers in Sri Lanka. *Journal of Agribusiness in Developing and Emerging Economies*, 6 (1), Pp39-58.

Saiyut, P., I. Bunyasiri, P. Sirisupluxana, and I. Mahathanaseth. (2018). The Impact of Age Structure on Technical Efficiency in Thai Agriculture. *Kasetsart J. Soc. Sci*. 39(3), 1-7. Doi: 10.1016/j.kjss.2017.12.015

Salvioni, C., Henke, R., & Vanni, F. (2020). The Impact of Non-Agricultural DiversificationOn Financial Performance: Evidence from Family Farms in Italy. *Sustainability*, 12(2), pp. 486

Sandika, A.L. (2011). Impact of Middlemen on Vegetable Marketing Channels in Sri Lanka. Kamburupitiya: Sri Lanka Tropical Agricultural Research & Extension.

Sarantis, M (2016) Africa's Farming Potential Hinges on Infrastructure Boost. EURACTIV.com

Sarker, C. and Rahim, M. (2013). Yield And Quality of Mango (*Mangifera indica L.*) As Influenced By Foliar Application of Potassium Nitrate And Urea. *Bangladesh Journal of Agricultural Research, 38,* 145-154.

Schouten, G. and Vellema, S. (2019). Partnering for inclusive business in food provisioning. Curr. Opin., *Environ. Sustain*. **2019**, 41, 38–42

Scoones, I. (2009). Livelihoods Perspectives and Rural Development. *Journal of Peasant Studies*, Vol. 36, No. 1.

Seid, H and Zeru, Y (2013) Assessment of Production Potentials and Constraints of Mango (Mangifera Indica) at Bati, Oromia Zone, Ethiopia. *International Journal of Sciences: Basic and Applied Research*, Vol. 11(1):1-9

Sennhenn, A., Prinz, K., Gebauer, J., Whitbread, A., Jamnadass, R., and Kehlenbeck, K. (2013). Identification of Mango (*Mangifera indica* L.) Landraces from Eastern and Central Kenya using a Morphological and Molecular Approach. *Genetic Resources and Crop Evolution,* 6, pp. 7–22

Serem, A. (2010). Challenges in Production and Marketing of Mangoes in Kenya. Nairobi: HCDA.

Shaaban, S., and Shaaban, M. (2012). Impact of the Nutritional Status on Yield of Nine Mango Cultivars Grown Under Farm Conditions at Giza Governorate, Egypt. *Journal of American Science* 8(5) : 304-310.

Sharma, S. (1996). Applied Multivariate Techniques. New York: John Wiley and Sons Inc.

Sheahan, M., & Barrett, C. (2014). Understanding the Agricultural Input Landscape in Sub-Saharan Africa: Recent Plot, Household, and Community Level Evidence. *Policy Research Working Paper* 7014. Washington, DC: World Bank

Shiferaw, B., Hellin, J and Muricho, G (2016). Markets Access and Agricultural Productivity Growth in Developing Countries: Challenges and Opportunities for Producer Organizations. 10.4337/9781784719388.00013.

Sisay, M. (2010). Export Performance and Determinants in Ethiopia. MPRA Paper 29427, University Library of Munich, Germany.

Sivakumar D, Jiang Y, and Yahia, M. (2011). Maintaining Mango (*Mangifera indica* L.) Fruit Quality during the Export Chain. *Food Research International* 44:1254-1263.

SOFA Team and Doss, C., (2011). The Role of Women in Agriculture. Agriculture and Economic Development Analysis Division. *FAO Agricultural Working Paper*, No. 11-02

Starkey, P (2016). Personal observations and interviews. Ghana, February 2016.

Starkey P, Njenga P, Kemtsop G, Willilo S, Hine J, Odero K, Mbathi M and Opiyo R (2013a). Rural transport services indicators: guidelines to the methodology, September 2013. International Forum for Rural Transport and Development (IFRTD) Project

AFCAP GEN/060. London. African Community Access Programme (AFCAP). 176p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

Starkey P, Njenga P, Kemtsop G, Willilo S, Opiyo R and Hine J (2013b). Rural transport services indicators: Final Report, August 2013. International Forum for Rural

Transport and Development (IFRTD) Project AFCAP GEN/060. London. African Community Access Programme (AFCAP). 158p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

Stephanie, G. (2020). "Kaiser-Meyer-Olkin (KMO) Test for Sampling Adequacy" From **StatisticsHowTo.com**: Elementary Statistics for the rest of us! https://www.statisticshowto.com/kaiser-meyer-olkin/

Stilwell, T. and M. N. Makhura. 2004. Rural infrastructure development. Paper presented during DBSA Knowledge Week. 2004, November 1-5. Midrand, South Africa.

Tabachnick, B and Fidell, S. (2013). Using Multivariate Statistics, 6th Edition. Northridge, California: Pearson Publishers

Takele, H (2014). Review of Mango Value Chain in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, Vol. 4, No. 25, 2014

Tewodros, B., Neguse, F., Wanzala, R., Wassu, M. Ali, Owino, W and Githiri, S., Mwangi, S. (2014) Production Scenarios of Mango (Mangifera indica L) in Harari Regional State. *Eastern Ethiopia Science, Technology and Arts Research Journal Sci Technol Arts Res J* 3(4): 59-63.

Tewodros, N., Rimberia, F., Mohammed, W., Willis, O., & Githiri, S. (2019). Mango (*Mangifera indica L.*) Production Practices and Constraints in Major Production Regions of Ethiopia. *African Journal of Agricultural Research*, Vol. 14. 185-196.

Thacker, S., Adshead, D., Morgan, G., Crosskey, S., Bajpai, A., Ceppi, P., Hall, O'Regan, N. (2018). Infrastructure: Underpinning Sustainable Development. UNOPS, Copenhagen, Denmark.

Thamaga-Chitja, J. (2012). How Has the Rural Farming Woman Progressed Since the Setting Up Of The Millennium Development Goals For Eradication Of Poverty And Hunger? *Agenda 2012*, 26, 67–80.

The Development Fund. (2011). *A Viable Food Future.* Oslo: Utviklingsfondet

The World Bank. (2008). Agriculture for Development. *World Development Report 2008.* New York: The World Bank

Tingem, M., Rivington, M. & Bellocchi, G. (2008). Adaption Assessments for Crop Production in Response to Climate Change in Cameroon. *Agronomy for Sustainable Development. Vol. 29,* 247-256.

Tobin, D., Glenna, L. and Andre Devaux, A. (2016). Inclusion and Exclusion in Native Potato Value Chains in the Central Highlands of Peru. *Journal of Rural Studies,* 46, Pp71-80.

Torbjorn, A. and Bharat, P. (2012). Contribution of Rural Roads to Access to- and Participation in Markets: Theory and Results from Northern Ethiopia. *Journal of Transportation Technologies*, 2, pp 165-174.

Twumasi, M., Jiang, Y., & Acheampong, M. (2019). Determinants of Agriculture Participation Among Tertiary Institution Youths in Ghana. *Journal of Agricultural Extension and Rural Development,* 11(3), 56-66.

Ugese, F., Iyango, P., & Swem, T. (2012). Mango (Mangifera Indica L.) Fruit Production and Production Constraints in Gboko Local Government Area of Benue State. *Production Agriculture and Technology,* 8(1), pp 164-174.

UN. (2008). Sustainable Development Goals. Washington DC: World Bank

UN Food and Agriculture Organization (2011). The State of Food and Agriculture 2010–2011: Women in Agriculture: Closing the Gender Gap for Development. Rome: FAO

UNESCO (2010).. The African Great Rift Valley - The Marakwet Escarpment Furrow Irrigation System. Department of Museums, Sites and Monuments of the National Museums of Kenya. UNESCO: World Heritage Centre

Van Melle, C., & Buschmann, S. (2013). Comparative Analysis of Mango Value Chain Models in Benin, Burkina Faso and Ghana. In, Rebuilding West Africa's Food Potential, A. Elbehri (Ed.). Rome: FAO/IFAD.

Venkatachalam, L. (2003) Infrastructure and Agricultural Development in Karnataka State, Institute for Social and Economic Change, Nagarbhavi, Bangalore.

Wabwoba M. S. N and Jacob W. W. (2013). Factors affecting sustainability of community food security projects in Kiambu County, Kenya. Unpublished MBA thesis. University of Nairobi

Warner, M., Kahan, D and Lehel, S. (2009). Market-oriented Agricultural Infrastructure: Appraisal of Public-private Partnerships. Food and Agriculture Organization of the United Nations. Rome, Italy: FAO

Wells, B. and S. Gradwell. (2011) Gender and resource management: Community supported Agriculture as caring-practice. Journal of Agriculture and Human Values. 18. 107.

Whande,W. (2010). Reverse Rural-Urban Migrations: An Indication of Emerging Patterns in Africa. Institute of Security Studies. https://issafrica.org/iss-today/reverse-rural-urban-migrations-anindication-of-emerging-patterns-in-africa

Willilo S and Starkey P (2013). Rural transport service indicators: report of the Iringa-

Kilolo Road, Tanzania. June 2013. International Forum for Rural Transport and Development (IFRTD) Project AFCAP GEN/060. London. African Community Access Programme (AFCAP). 27p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

Willilo S and Starkey P (2012). Rural Transport Service Indicators: Tanzania Country Report. September 2012. International Forum for Rural Transport and Development (IFRTD) Project AFCAP GEN/060. London. African Community Access Programme (AFCAP). 57p. Available at: http://www.ruraltransport.info/RTSi/resources/project_outputs.php

World Bank. (2012). World Development Report 2012: Gender Equality and Development. Washington, DC: World Bank

World Bank. (2018). World Development Indicators. Washington, DC: The World Bank. World Bank. (2018). Maximizing Finance for Development *(*MFD*)*. Washington DC: World Bank

World Bank. (2008). World Development Report on Agriculture and Poverty Reduction. Washington DC: World Bank

World Bank (2005), Agriculture and Achieving the Millennium Development Goals, Report No. 32729- GLB, Agriculture and Rural Development Department, Washington DC

Yilma, T (2009). United Nations Conference on Trade and Development. UNCTD

APPENDIX I: QUESTIONNAIRE FOR THE MANGO FARMERS IN KERIO VALLEY ESCARPMENT

Please answer these questions to the best of your knowledge. Please put a tick [ ] where appropriate. Do not include your name anywhere in the questionnaire.

A	**BACKGROUND INFORMATION**	
1.	Gender	1. Male [ ] 2. Female [ ]
2.	Age	1. 0 - 20 [ ] 2. 21-35 [ ] 3. 36- 50 [ ] 4. >51 [ ]
3.	Please tick your education level	1. Never Attended [ ] 2. Primary [ ] 3. Secondary [ ] 4. College [ ]
4.	What is your marital status	1. Married [ ] 2. Widowed [ ] 3. Divorced/Separated [ ] 4. Never married [ ]
4.	Please tick your County	[ ] [ ]
5.	Number of people in the household	1. 1 - 4 [ ] 2. 5-9 [ ] 3. 10-12 [ ] 4. Above 13 [ ]
6.	**What is the size of land under mango production?**	
7.	How many years have you been in mango production	

8.	How was your mango farm land acquired?	1. Outright purchase [ ] 2.Rented Land [ ] 3.Family Land [ ] 4.Community land [ ]
9.	Is mango production your primary or secondary occupation?	1. Primary [ ] 2. Secondary [ ]
10.	What is your motivation for growing mangoes	1. Shade [ ] 2. Domestic fruit consumption [ ] 3. Income to support family [ ] 4. Making profit [ ] 5. As a way of life [ ] 6. Only option [ ]
11.	Apart from mango farr what other major econ activities	1.Cash crop farming 2. Dairy farming 3. Goat Farming 4. Bee Keeping 5.Poultry Keeping 6. Tree seedling .9 Others (Specify)…….
12.	Range of Income Per month from mango farming	1. Below 5000 [ ] 2. 5,001-20,000 [ ] 3. 20,001-35,000 [ ] 4. 35,001-50,000 [ ] 5. Above 50,001 [ ]
B	**AGRICULTURAL INFRASTRUCTURE**	
13.	Which variety of mango do you grow	1. Apple [ ] 2. Ngoe [ ] 3. Tommy [ ] 4. Fantaic, [ ] 5. Keit [ ] 6. Keint [ ]

14.	How many times do you spray the mango per season	1. Once [ ] 2. Twice [ ] 3. Thrice [ ] 4. Four times [ ] 5. More than four times [ ]
15.	Which type of spraying equipment do you use?	1. Traditional [ ] 2. Knapsack [ ] 3.Motorised pump [ ]
16.	What is the mode of transport for your mango fruits to the market?	1. Lorry [ ] 2. Motorcycle [ ] 3. Bicyc [ ] 4. Pick up [ ] 5. Wheel Barrow [ ] 6. Animal cart [ ]
17.	Do you at times refrigerate mangoes or treat them with combined preservatives?	1. YES [ ] 2. NO [ ]
18.	Have you been trained on nursery management and grafting techniques?	1. YES [ ] 2. NO [ ]
19.	Have you been trained on value addition technologies?	1.YES [ ] 2. NO [ ]
20.	Please indicate the sources of agricultural information during the last 12 months (Multiple responses allowed)	1. Radio/TV/ Newpaper [ ] 2. Extension Officer [ ] 3. Farmer Groups [ ] 4. Neighbour/Friend/ Relative [ ] 5. Mobile Phone [ ] 6. NGO [ ] Government Office [ ]
21.	Where do you sell mangoes?	1. Farm Gate [ ] 2. Middlemen come and buy [ ]

		3.Market yard in the Village [ ] 4.Urban Market [ ] 5.Export Market[ ] 6. Processing Unit [ ]
22.	Do you Sort Mangoes before selling to secure higher prices for higher quality produce?	1. YES [ ] 2. NO [ ]
23.	How did you finance mango related operations in the last season	1. Saving [ ] 2. Friends/Relative [ ] 3. Financial Institutions [ ] 4. Micro Finance [ ] 5. Cooperatives [ ] 6.Mobile apps [ ]
24.	Indicate barriers to the access to credit services from the above mentioned institutions?	1. Low income [ ] 2. Outstanding loans [ ] 3. Lack of security / collaterals [ ] 4. Inaccessible credit providers [ ]
	Specify your level of agreement on the extent of access to the following agricultural infrastructure. Strongly Agree (5), Somewhat Agree (4), Neutral (3), Somewhat Disagree (2) and Strongly Disagree (1)	

		5	**4**	**3**	**2**	1
25.	Agricultural Infrastructure					
26.	Electricity					
27.	Agro processing plants					

28.	Storage facilities				
29.	Irrigation facilities				
30.	Access to dam water				
	Please indicate the level of agreement on role of middlemen in marketing mango fruits				
31.	Middlemen provide the most convenient method of selling mango fruits.				
32.	Middlemen have better access to the mango fruit market than farmers.				
33.	Middlemen are more knowledgeable on marketing than mango farmers				
34.	Do you think middlemen exploit mango farmers unfairly?				

SECTION C: EFFECTS OF AGRICULTURAL INFRASTRUCTURE ON SMALL HOLDER FARMING

Using the following scale, please tick the one that best describes your opinion: **Strongly Agree (5), Somewhat Agree (4), Neutral (3), Somewhat Disagree (2) and Strongly Disagree (1)**

		SA	A	UN	D	SD
35.	Availability of quality planting seeds has led to increased output					
36.	The availability of farm machinery has enhanced the carrying out timely field operations.					
37.	We have seasonal and tarmac roads which has enhance the transportation of farm inputs and outputs					

38.	There has been deduction in cost of transportation from farm to market due to availability of good transport networks					
39.	We have proper storage which has improved the safeguarding of farm produce and helps for securing good prices and also acts as an insurance against distress sale of produce					
40.	Availability of cold storage protects the perishable produce from spoilage, besides, helps in getting higher income to farmers.					
41.	We can access agro processing facilities that add value to mango production.					
42.	Value addition, packing, branding and good marketing network also adds to the income of the farmer.					
43	We have electricity in the area which has helped us in pumping water for irrigation					
44.	We have cooperative societies in the area which helps us to save our income as well as getting loans from them					
45.	We have farmers' unions which we use to get market for our farm inputs as well as getting education on quality farm inputs					
46.	There are financial institutions in the area which provide us loans with affordable interest during farming process					
47.	The availability of agricultural research facilities in the area has enhanced the quality production of agricultural outputs					
48.	Access to agricultural extension has significantly increased adoption of modern input such as chemical fertilizer and improved seeds.					

SECTION D: CHALLENGES OF AGRICULTURAL INFRASTRUCTURE ON SMALL HOLDER FARMING

Using the following scale, please tick the one that best describes your opinion

Strongly Agree (5), Somewhat Agree (4), Neutral (3), Somewhat Disagree (2) and Strongly Disagree (1).

		SA	A	UN	D	SD
49.	Lack of certified and availability of quality planting seeds					
50.	High price of fertilizers and Lack of timely availability of fertilizers					
51.	Lack of availability and High price of pesticides					
52.	Lack of agricultural labour during peak seasons					
53.	Lack of information about recommended package					
54.	High incidence of pests and diseases					
55.	Lack of availability of proper plant protection equipment					
56.	No irrigation facilities					
57.	Inadequate irrigation facilities					
58.	Low availability of irrigation power					
59.	High cost of irrigation power					
60.	Lack of capital resources and collaterals					
61.	Lack of credit availability from institutional sources					
62.	High cost of credit					
63.	Lack of marketing facilities at village level					
64.	Low price of farm produce at the time of harvesting					
65.	Lack of storage facilities					

66.	Lack of cheap and efficient transport					
E	**ROLE OF GOVERNMENT IN AGRICULTURAL INFRASTRUCTURE**					
	The government is providing subsidized inputs for farmers					
	Through the government funding there is adequate access to water for irrigation and electricity.					
	The county government and institutions promote and support farmer's unions and cooperatives.					
	The government has invested in road infrastructure in the region					
	The county government is directly involved in streamlining mango prices.					
	The county government institutions create direct links to final consumers of mangoes through marketing.					

APPENDIX II: KEY INFORMANT INTERVIEW SCHEDULE

1. Which is the superior mango variety that farmers are adopting?

2. Are the mango farmers trained on the right spacing, right seeding and crop maintenance (watering, weed control, pruning, pest and diseases control)?

3. Is there any sensitization on quality and hygiene requirements in mango production management?

4. In the Counties level do you have any policies on mango production?
5. Are there any agro processing industries for mango processing access to farmers in Kerio Valley escarpment?
6. Do you think the adoption of Mango farming in Kerio Valley has attempted to address the development needs of the people in terms of poverty reduction and food security?
7. Who are the various stakeholders supporting the mango farmers in the region?
8. In your opinion, what are the accrued benefits of adoption of agriculture infrastructure by mango farmers in the region?
9. Identify and explain Challenges /constraints in adoption of agriculture infrastructure of mango farming in the region?
8. What are some of the workable solutions to the above dynamics?

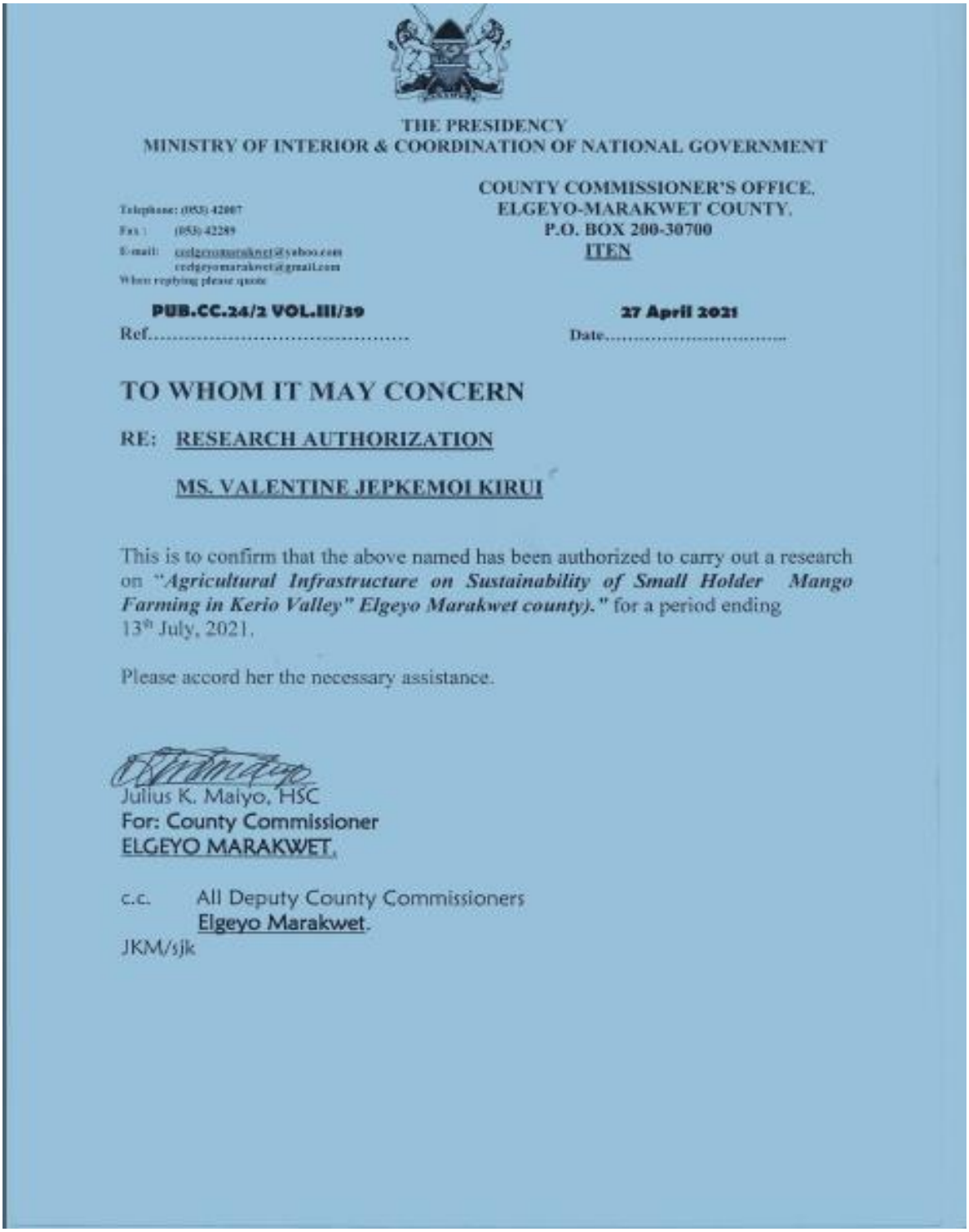
APPENDIX III: FOCUSED GROUP DISCUSSIONS

1. What are the other activities that farmers are engaged in apart from mango farming?
2. What is the main role of county government in mango farming?
3. What has been improved in terms of Agricultural infrastructure for the last five years?
4. Who are the stakeholders supporting farmers in the region?
5. In your opinion, do you think mango farming has led to food security and poverty reduction in the community?
6. Do you think farmers are adopting modern technologies?
7. What are some of the benefits that mango are enjoying after improvements of agricultural infrastructure?
8. What are the dynamics affecting the adoption of agriculture infrastructure in mango farming?

APPENDIX IV: OBSERVATION GUIDE

1. Mango trees
2. State of roads
3. Agro processing facilities
4. Available irrigation facilities
5. Mango collection points
6. Electricity connections in the community

AUTHORITY LETTER FROM - NACOSTI



THE PRESIDENCY
MINISTRY OF INTERIOR & COORDINATION OF NATIONAL GOVERNMENT

COUNTY COMMISSIONER'S OFFICE,
ELGEYO-MARAKWET COUNTY,
P.O. BOX 200-30700
ITEN

Telephone: (053) 42007
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cedgeyomarakwet@gmail.com
When replying please quote

PUB.CC.24/2 VOL.III/39 — Ref.....

27 April 2021 — Date.....

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION

MS. VALENTINE JEPKEMOI KIRUI

This is to confirm that the above named has been authorized to carry out a research on ***"Agricultural Infrastructure on Sustainability of Small Holder Mango Farming in Kerio Valley" Elgeyo Marakwet county)."*** for a period ending 13th July, 2021.

Please accord her the necessary assistance.

Julius K. Maiyo, HSC
For: County Commissioner
ELGEYO MARAKWET.

c.c. All Deputy County Commissioners
Elgeyo Marakwet.
JKM/sjk

REPUBLIC OF KENYA
MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

TELEGRAM:.....
TELEPHONE NO: 0534142207
WHEN REPYLING PLEASE QUOTE OUR REFERENCE
EMAIL: cdeelgeyomarakwet@gmail.com

COUNTY DIRECTOR OF EDUCATION
ELGEYO MARAKWET COUNTY
P.O. BOX 214-30700
ITEN

DATE: 27th April 2021

REF No: ***CDE/EMC/R/26/VOL.III/ (39)***

Valentine Jepkemoi Kirui
Moi University
P.O. Box 3900
ELDORET

RE: RESEARCH AUTHORIZATION- VALENTINE JEPKEMOI KIRUI
SHRD/PHDS/02/16

Following the authorization by the National Commission for Science, Technology and Innovation **(NACOSTI)** to carry out research in **Elgeyo Marakwet County** Vide Authority letter **Ref. No. NACOSTI/P/ 20/5723** dated **13th July, 2020** you are hereby formally granted authority by this office to proceed with your study on ***"Agricultural Infrastructure on Sustainability of Small Holder Mango Farming in Kerio Valley in Elgeyo Marakwet County*** for a period ending **13th July, 2021.**

You are further required to report to the Sub-County Directors of Education –Elgeyo Marakwet County.

FOR: COUNTY DIRECTOR OF EDUCATION
ELGEYO MARAKWET
P. O. Box 214 - 30700,
ITEN

Okwemba O.V
For: County Director of Education
ELGEYO MARAKWET

Copy to:
1. The Director General/CEO -NACOSTI
2. The Sub-County Directors of Education- **Elgeyo Marakwet County**

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 154277

Date of Issue: 13/July/2020

RESEARCH LICENSE

This is to Certify that Ms.. VALENTINE JEPKEMOI KIRUI of Moi University, has been licensed to conduct research in Baringo, Elgeyo-Marakwet on the topic: Agricultural Infrastructure on Sustainability of Small Holder Mango Farming in Kerio Valley, Kenya for the period ending : 13/July/2021.

License No: NACOSTI/P/20/5723

154277

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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