

**RESPONSIVENESS OF HORTICULTURAL PRODUCTION TO INFRASTRUCTURE
DEVELOPMENT IN KENYA**

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Declaration

I hereby declare that this is my original work which is yet to be submitted to any university for a degree award.

Signature.....Date.....

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X50/76207/2012

Supervisor's Recommendation

This project has been presented for examination with my approval as university supervisor.

Signature.....Date.....

John Gathiaka, PhD

Dedication

I dedicate this work to my lovely children, Bola, Argwings and Albertina, whose future holds promise
beyond horizons.

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First, my appreciation goes to my supervisor, Dr. John Gathiaka, whose insights, instructions and comments made this work a success. Secondly, I am grateful to my lecturers and the entire fraternity at the School of Economics, University of Nairobi for the role they played during my study and towards this project.

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Abbreviations/Acronyms

ADB	African Development Bank
ERC	Energy Regulatory Commission
KeNHA	Kenya National Highway Authority
KeRRA	Kenya Rural Roads Authority
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya Bureau of Statistics
KRB	Kenya Roads Board
ROK	Republic of Kenya
KURA	Kenya Urban Roads Authority
REA	Rural Electrification Authority
SOC	Social Overhead Capital
LDCS	Least Developed Countries

Abstract

Empirical evidence indicates that development of infrastructural such as irrigation, education, roads and electricity, has a positive effect on agricultural production. In Kenya, road transport, electricity and irrigation are key components of agricultural development. However, literature on their impact on horticultural production are scant especially in developing countries. This study investigated how horticultural production responds to infrastructure development in Kenya. It relied on secondary data from Tegemeo Institute covering 2000, 2004, 2007 and 2010 for analysis. The study used Fixed effect model to estimate results. Findings show that the value of horticultural production responds positively to the developments in paved roads, and irrigation infrastructure. Similarly, the size of a farm under horticultural farming influences production positively. Conversely, horticultural production was found to have a negative response to unpaved roads and daily labour hours on the farm. The study recommends increased investment in the construction of paved roads by both national and county government. In addition, the government needs to emphasize on irrigation facilities especially in rural areas.

CHAPTER ONE

INTRODUCTION

1.1 Background

There is a suggestion from existing literature that road infrastructure and irrigation are key drivers of agricultural productivity particularly in emerging economies (Andersen & Shimokawa, 2007). Majority of people (about 75 percent) in developing countries reside in rural areas where most of the residents derive their livelihood from agriculture (Nagler & Naudé, 2017). Thus, efficient infrastructure is a critical driving force of the growth rural economy. Studies show that rising agricultural production hinges on good road networks, effective markets, functional institutions as well as accessibility to suitable technology (Andersen & Shimokawa, 2007 and Burgess et al., 2016). The agricultural sector in Kenya is characterized by poor infrastructure including impassable roads and ineffective service institutions.

Road, electricity and irrigation infrastructure are significant inputs in agricultural development. The World Bank (1997) estimates that 15% of crop production in rural areas is lost due to poor road networks and poor storage infrastructure. The loss negatively affects farmer income. Good road network promotes physical linkages and integration between the rural agricultural sector and the urban markets. it expands global markets. This leads to more sales, enhanced job opportunities, economic growth and hence poverty reduction (Manasan & Chatterjee, 2003). Efficient road systems especially in agricultural areas enhance Production through cheaper and efficient transportation of outputs to the markets (Inoni, 2009). On the other hand, irrigation enables farming both in and out of season, while electricity is very fundamental in facilitating establishment of better storage to avoid post-harvest losses as well as mechanization in agriculture.

1.1.1 Kenya's Investments in Road, Irrigation and Electricity Infrastructure

Kenya's vision 2030 underscores the role of road infrastructure on the overall development of the economy (Republic of Kenya, ROK, 2008). Road network dominates Kenya's transport sector with almost 93 percent of passenger and freight cargo being moved by road (Kenya Roads Board, KRB, 2017). There are five classes of roads in Kenya namely; A, B, C, D and E. Class A, are the roads connecting points on international importance such as airports and boarder points. Class B roads link administrative centres facilitating access to government services. Class C roads connect rural towns and villages, while class D roads are secondary routes and class E are minor roads. Presently, Kenya has 61936 kilometers of classified roads and 98,950 kms of unclassified roads. Classes A-E roads are further classified as paved and unpaved roads. Paved roads are considered roads of high quality, while unpaved are made from natural materials considered as low quality.

Since 2002, the government has had concerted efforts to increase road network, re-carpet dilapidated roads and construct new roads across the country. These efforts have been pursued through various road agencies which are: Kenya Urban Roads Authority (KURA), Kenya Rural Roads Authority (KeRRA), Kenya Roads Board and the Kenya National Highway Authority (KeNHA) (Kenya Roads Board, 2018). Based on the board's inventory survey of 2009, Kenya has 161,451.3 kms of roads.

Regarding irrigation, there is evidence that it is among key infrastructural resources influencing agricultural production in both developed and developing countries (Hine et al., 2016). Irrigation can enable farming in areas which receive little or no amount of rainfall such like most parts of

North Easter Kenya characterised with arid and semi-arid conditions. In addition, irrigation makes it necessary for farmers to plant crops in and out of season.

Globally, Kenya is categorized among water deficient countries (Donaldson and Hornbeck, 2016). There is uneven distribution of water resources in Kenya where approximately 56 percent of such resources are confined around the Lake Victoria basin. The Ministry of water and irrigation has the mandate to formulate water management policies and ensure sufficient water resources for farming, domestic and industrial utilization. Farming under irrigation in Kenya is conducted mainly in large plantations particularly those of rice, sugar cane, tea and coffee as well as in the irrigation schemes (Njenga et al, 2014). Some individual farmers especially those involved in farming for export crops such as coffee and horticulture have developed their own irrigation systems.

As with irrigation, literature indicates that electricity is a very important input in agricultural production. Electricity or energy is needed in agriculture to operate machinery and equipment, to cool or heat storage facilities, lighting on the farm and in the manufacturing process for fertilizers and other chemicals (World Bank, 2015). In the last two decades, various reforms in the electricity sub-sector have put operationalized by the Kenyan government to increase access to electricity in rural areas where farming takes place (African Development Bank (ADB), 2015). Key among them is the establishment of Rural Electrification Authority (REA) and Energy Regulatory Commission (ERC) and Public Private Participation (PPP). The reforms were meant to enhance efficiency and lower tariffs for most households to afford electricity. However, the effect of investments in irrigation and electricity projects on horticultural remain unclear.

1.1.3 Horticultural Farming in Kenya

Kenya's horticulture has experienced growth in the last two decades becoming a key contributor to foreign income and employment (Gollin & Rogerson, 2014). Presently, horticulture sub-sector is rated as the second fastest growing industry in Kenya in terms of foreign trade earnings after tea (Allen & Atkin, 2016; Kenya Bureau of Statistics (KNBS), 2017). Horticulture farming encompasses the growing of vegetables, flowers and fruits. The crops planted in Kenya under horticultural farming are summarized in Table 1.1

Table 1.1: Horticultural crops in Kenya

Category	Crop
Flowers	Roses, arabicum, lilies, cut foliage, rudbeckia, carnations, carthamus
Vegetables	Cabbage, cauliflower, lettuce, basil, artichoke, arrow roots
Fruits	Bananas, apples, mangoes, melon, passion, oranges, pawpaw, bixa, avocado

Source: Export Processing Zone (2005).

In Kenya, horticultural farming is extensively practiced in Mount Kenya region (Kirinyaga, Muranga, Nyeri and Kiambu), Eastern region (Meru and Machakos), Nyanza (Kisii) and Rift valley region (Nakuru, Baringo and Naivasha). While large scale farmers dominate export sector, majority of these horticultural farmers in Kenya practice farming on small scale (KIPPRA, 2013). Based on the Kenya National Bureau of Statistics (KNBS), 96 percent of the total production in this sub-sector goes to the local market while the export market accounts for the remaining 4

percent of total products (KNBS, 2017). The sector’s earning from exports increased by 9.2 percent from Ksh100,963 billion in 2015, to Ksh110, 338 billion in 2016. Figure 1.1 indicates that flowers account for the largest share of horticultural exports, while vegetables contribute the least.

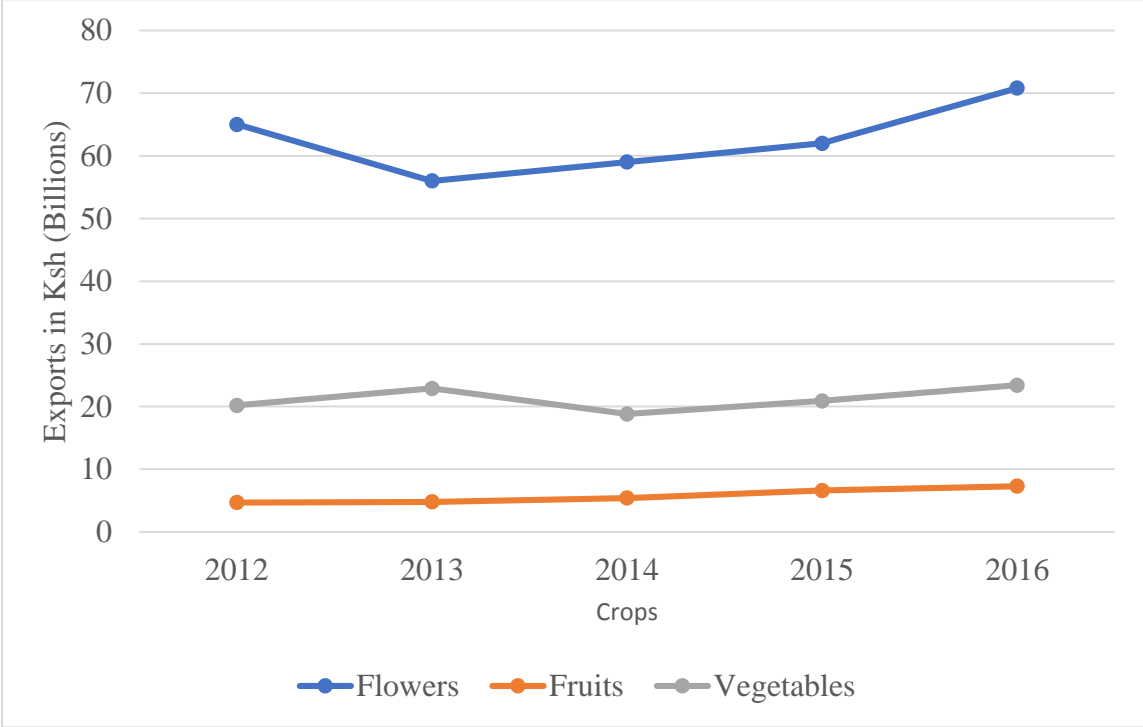


Figure 1.1: Horticultural exports from Kenya 2012-2016 (Ksh billion)

Source: KNBS, 2017

Figure 1.1 indicates a steady rise in horticultural exports from 2013. However, the growth in flowers was relatively steadier than that of vegetables. Fruits have relatively performed well from 2014 up to date.

1.2 Research Problem

Empirical findings indicate that there is a link between infrastructural development and production in agriculture. For instance, Fan and Zhang (2004) for the case of Thailand, was reported that investment in irrigation, education, roads and electricity have positive but, marginal effects on

agricultural production. Similar findings have been reported in both developed and developing economies around the world (Manasan & Chatterjee, 2003; Andersen & Shimokawa, 2007; Inoni & Omotur, 2009; Hine et al.,2016). In Kenya, studies have reported positive effects of infrastructural investment on agricultural production in general and not horticultural production (Hine & Bradbury, 2016; Were, 2016 and Njenga et al., 2014).

The government of Kenya and its development partners have channeled substantial investment towards these infrastructures for the last two decades with an aim of making transport smoother and cheaper, reduction of post-harvest loses through better storage systems, and ensuring that agricultural production is not interrupted because of inadequate amounts of rainfall. Investment in road infrastructure could in turn enhance efficiency of transport of input and outputs within the agricultural sector and hence productivity (Aggarwal, 2015).

There is limited literature on the effect of road, electricity and irrigation investment on agricultural performance in general, and horticulture in particular for the case of developing countries. The available few studies have focused on the impact of large-scale infrastructure in general on a country's economic activities (Manasan & Chatterjee, 2003; Donaldson, & Hornbeck, 2016). Little attention is paid to the impact of small-scale infrastructural networks, a necessary component of rural agricultural development but outside this study. In particular, little is known about the effect of road, electricity and irrigation infrastructure development on horticultural production in Kenya, the second most important contributor to foreign earnings.

1.3 Research Questions

The following questions were formulated to guide the study:

- i. How does horticultural production respond to road infrastructural development in Kenya?
- ii. How does horticultural production respond to electricity infrastructural development in Kenya?
- iii. What is the responsiveness of horticultural production to irrigation infrastructural development in Kenya?

1.4 Objective

General objective was to explore the responsiveness of horticultural production to infrastructure development in Kenya. Specific objectives were:

- i. To determine the responsiveness of horticultural production to increase in number of kilometers of paved roads in Kenya;
- ii. To determine the responsiveness of horticultural production to irrigation investment in Kenya;
- iii. To determine the responsiveness of horticultural production to electricity access expansion in Kenya.

1.5 Justification of the Study

Horticultural farming in Kenya is the second most foreign income earner after tea. There is evidence that road infrastructure, irrigation and investment in electricity plays a key role towards agricultural growth and development. Several reforms have been carried out in Kenya's road network, irrigation and electricity access with an aim of increasing agricultural productivity. However, there exists limited empirical evidence on the effect of Kenya's road network, irrigation and electricity access on horticultural productivity in particular. This study therefore, fills this knowledge gap. This study is envisaged to add to existing knowledge and debate and hopefully strengthen the empirical basis for assessing the impact of infrastructural reforms on horticultural

productivity. This study raises various important questions which can be taken up by future researchers for a deeper understanding of the role of infrastructure on agricultural productivity. Therefore, the findings of this study could be used as a spring board upon which other studies in this field will be based.

In addition, the findings of the study could be instrumental to policy makers. In particular, the government could take the initiative to open up more agricultural areas through investment in paved roads based on these findings, enhance irrigation schemes in the country and improve electricity access in rural areas. This could in turn increase revenues for farmers, create more jobs and contribute immensely to economic growth. Furthermore, findings of this study could be used as reference point by other researcher in future.

1.6. Organisation of the Study

Following this introduction chapter, chapter two of the study comprises of literature review where, both theoretical and empirical evidence are presented. In addition, the chapter presents summary of empirical review. The third chapter presents the methodology followed in conducting the study which includes: theoretical and analytical models, data as well as model estimation techniques. The fourth chapter presents findings and interpretation of the results, and lastly, the fifth chapter comprises of the summary, conclusion and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews both theory and empirical literature relevant to the study (responsiveness of agricultural production on infrastructural development). In addition, summary and research gaps are also presented at the end of the chapter.

2.2 Theoretical Literature Review

There are various theories linking infrastructure and economic activities. In his stages growth, Rostow (1960) argued that investment in social overhead capital is a pre-condition for sustainable development. According to him, investing in social overhead capital motivates potential investors to commit their funds in risk-bearing ventures. This is because, it is a foundation upon which economic activities could be increased through cost reduction and therefore, enhanced productivity. Investment in social overhead capital also aids in human capital development, superior communication and energy structures, a pre-requisite for growth and development of the economy. These contribute to conducive atmosphere which in turn breeds entrepreneurial capacities for growth. Additionally, Rostow theory holds that investment in social overhead capital particularly in the area of transport and energy, is very key for economic take-off. Indeed, the theory observe that road network is very crucial for the development of economic activities and particularly promotion of agriculture (Andersen & Shimokawa, 2007; Burgess et al., 2016).

On his part, Hirschman (1958) developed a conceptual framework on social overhead capital (infrastructure) which comprised of services such as transport, communication, health, irrigation as drainage systems. In his thinking, Hirschman argues that these services are the primary,

secondary and tertiary activities and that without them, no any economic activity can take place. The whole of this concept revolves around two items, that is, transport and energy. According to his theory of unbalanced growth on the Least Developed Countries (LDCs), there is no LDCs which has enough resources so as to invest in many sectors and realize balanced growth at the same time. The theory holds that investing in critical sectors like transport, will bring about new investment opportunities and give way for the expansion of the economic activities. Accordingly, it is advisable to commit investment in infrastructure to boost production activities. Hirschman (1958) argues that for an activity to qualify inclusion in the social overhead capital (Infrastructure), such an activity must be able to facilitate more varieties of economic activities, and that these activities should be provided at no charge or at some control by a public authority. Transport (road infrastructure), and energy are an essential pre-condition for the growth of almost all sectors of the economy.

The development economist, Todaro (1981) underscores investment in the infrastructural facilities as the necessary conditions for economic activities to thrive. He states that investment in such facilities as machinery, human capital and other capital equipment enables the expansion of outputs to be realized by economic activities. According to Todaro, these activities are supplemented by other infrastructure such as roads, water, communication, electricity among others which helps to integrate economic activities. For instance, investment in tractor technology by farmers might lead to an increase in agricultural output, with well-established transport system. This view is underscored by the empirical work of Banjo et al. (2012) who argue that transport in the rural areas is very critical in agriculture production, where transport systems influence agricultural growth due their effect on market accessibility, and price fluctuations. Ashauer et al. (1989) argued that infrastructure is to be viewed in terms of overhead or capital costs and which

affects investment output. For example, Ashauer et al. (1989) in the case of the United States, noted that investment in physical infrastructural facilities such as roads, augments the performance of economic activities. This means that an increase in infrastructural investment has capability to increase productivity and living standards by extension.

Production theory has been used in literature to provide a link between infrastructural development and agricultural production (Dell et al.,2008; Aggarwal, 2015). Production is the conversion of production factors (inputs) into goods and services (outputs). This theory provides a functional relationship between inputs and outputs of a process. The output refers to the volume of goods or services produced while the inputs into the production process include factors such as: labour, capital, land, climatic condition as well as other environmental conditions. Various studies have used this theory to study agricultural production in different regions with infrastructure as one of the inputs (Dercon et al., 2007; Donaldson & Hornbeck, 2016; Hine et al., 2016). For example, Hine et al., 2016 held that provision of physical infrastructure such as electricity, education, roads and irrigation, boost farming in rural areas.

Following Arrow and Kurz (1970) seminal paper, the impact of infrastructure development on production has been modeled. Two approaches have been fronted, that is, amount of infrastructure undertaken, and secondly, the service rendered by infrastructure as a factor in the production process. These modeling presupposes that infrastructure is a gross complement between non-infrastructure inputs and capital. This then imply that as the volume of infrastructure service increases, the output is increased both directly and indirectly through crowding out effect of other inputs due to the accompanying increase in their marginal productivity (Cesar, & Luis, 2014). The indirect effect may occur suddenly for the case of variable inputs with elastic supply or as time goes by in the case of fixed inputs such as human and physical capital (non-infrastructure).

However, according to Barro (1990) endogenous growth model, infrastructural expansion has to be funded, and this brings a countervailing force, that is, the government has to increase tax in order to finance the infrastructure which could crowd out the adoption of some other inputs. This partially, or fully crowds out the effect through production. According to Barro, the contribution of the government to output is manifested in the flow of its expenditure and not the amount of capital which funded by income tax.

Several theories after Barro (1990) utilizes endogenous growth models which captures the impact of infrastructure on the economic growth rate in the long-run. However, most of these theories have largely focused on the infrastructure stock and not the infrastructure associated expenditure. The reasoning behind this turn of events is that, while the service rendered by infrastructure approach gives a significant advantage of tractability, availability of infrastructure such as roads, offers a close association with the stock of infrastructure. Based on this argument, Futagami, Morita and Shibata (1993) extended Barro (1990) framework by incorporating both public and private investment as a critical decision variable of the government. Following this modification, the model yields certain findings. While the economy shows nontrivial transactional changes, the growth maximizing level of government investment on the other hand, remains equal to elasticity of output regarding public capital, but welfare maximizing level is lower.

According to Hulten and Schwab (2006), infrastructure can also be incorporated into the production function as a determinant of technical efficiency. For instance, Agenor (2013) held that, telecommunication and transport services necessitate innovation and an upgrade of technology which lowers the cost of producing new varieties of inputs, and which ultimately raises production. Besides the role of infrastructure in production, the theory has also hypothesized that infrastructure plays a role in the accumulation of firm inputs. Turnovsky (1996) postulated that good transport

system could lower the installation of new capital equipment. Similarly, electricity access could enhance educational achievement and lower the cost of accumulating human capital (Agenor 2011). Thus, maximum share of output due to infrastructure expenditure is not just as a result of output elasticity but must also take into consideration, the effect of infrastructure on the accumulation of human capital.

The presence of network effects in the infrastructure is another feature which can explain the impact of investment in infrastructure on production. For instance, the contribution of roads to agricultural production may be limited to the lengths of the roads constructed.

In summary, the reviewed theories relate to the impact of the investment into infrastructure on economic activities in general. However, since roads are part of infrastructure, this study findings these theories are very instrumental in evaluating how construction/expansion of roads influences productivity of horticulture in Kenya.

2.3 Empirical Literature Review

The Asian Development Bank (ADB) (2007) noted that deficiencies in infrastructure are a crucial development obstacle in Philippines. The study argues that poor infrastructure raises the cost of crop farming and that this has negative impact on attractiveness and competitiveness of the outputs. In addition, the study found that investment in roads facilitates easy access to the market and thus, lowering the incidences of post-harvest losses especially for perishable commodities like vegetables, fruits and flowers as well. This in turn encourages more investment into farming and thereby leading to more production. Similarly, Inoni and Omotur (2009) in their study of 47 developing countries indicates that transport infrastructure contributes significantly to production in agriculture. This study was limited in the sense that it employed survey data which does not give more insights like the trend as opposed to panel data for the case of the current study.

Additionally, the focus of the study was on agriculture in general and not horticulture as for the current study. Furthermore, the study was not country specific and hence more difficult to single out the effect of infrastructure on agriculture for a specific country. Moreover, the study considered only road infrastructure and was not specific on any particular type of a road (paved versus unpaved) as for the case of the current study.

In another study, Fan and Zhang (2004) observed that investment in irrigation, roads and electricity has positive and marginal effects on the productivity of agriculture in Thailand. This study employed panel data methodologies to arrive at these conclusions. However, the effect of roads on agricultural production was more pronounced than that of electricity and irrigation. This study is faulted in the sense that the authors used expenditures on roads construction as a measure of development on roads. The challenge is that allocation cannot be the best measure. The current study corrected this by using distance of roads (paved and unpaved) from the household to the nearest road.

Manasan and Chatterjee (2003) in their study on the effect of roads on agriculture in Greece, found that 1 percent increase in road development explained 0.38 percent increase in agricultural production. This means that a decline in road network investment adversely impacts on the agricultural production. Again, the main focus in this study was roads and no other infrastructural developments such as irrigation, electricity, storage facilities among others. Had this been included, the findings could be different. In addition, the study did not provide a comparison on the effect of paved and unpaved road development on agricultural production as it is the case for the current study. A study by Craig et al. (1997) conversely, observed that expenditure on agricultural research, irrigation and road network are critical factors determining cross-country variations in the productivity of agriculture. Specifically, this study observed that expenditures on

infrastructure had a positive effect on agricultural production. However, the use of expenditures is not considered the best measure of infrastructural development in some several countries especially the developing world. In many developing countries, money allocated to different projects are either embezzled or diverted to other uses. The current study corrected this shortcoming by using more robust measures (distance of the road, access to electricity, and irrigation).

Studies have found that deficiencies in transportation, communication and other related infrastructure leads to poor functioning of local markets and undesirable international competitiveness (Andersen & Shimokawa, 2007). In addition, Andersen and Shimokawa observe that non-investment in rural roads would pose a threat to agricultural production, reduction of poverty and the output in the economy as a whole particularly for the case of developing countries. However, this study ignored other infrastructural developments such as irrigation and electricity. It also employed expenditures as proxy measure of road development which has been faulted by the current study. In a similar study, Thorat and Fan (2007) conclude that irrigation, electricity and transport deficiencies weaken huge prospects of the agricultural sector in the least developed countries. The study finds that irrigation encourages farming both in and out of the season which enhances production in agriculture. Furthermore, the study reported that access to electricity enables farmers to use modern ways of preserving especially perishable products like refrigeration of fruits and vegetables with the effect of reducing post-harvest losses. Moreover, the study noted that enhanced rural infrastructural network alleviate poverty through improved agricultural production with its related benefits such as creation of agricultural and non-agricultural jobs.

Dercon et al. (2007) carried out a study in India on the effect of irrigation, road infrastructure and electricity and observed a positive effect. A similar effect was reported for the non-agricultural

activities. However, the impact of roads was found to be bigger than that of irrigation and electricity. In addition, paved roads have a significant effect on agricultural growth than unpaved ones though significant. Even though the effect of unpaved roads was significant, their contribution to GDP in these studies were minimal.

Poor transport resulting from poor roads leads to high transport costs. Hine and Willilo (2015) holds that agricultural productivity is highly associated with accessibility to roads. Therefore, poor transport infrastructure could lead to reduced productivity in crop production. Similarly, Hine et al. (2016) argues that accessibility of the community necessitated by good transport services can improve people's livelihood through diversification of economic activities in rural areas. The World Development Report of 2008 supports the argument that production in the farm sector is associated with accessibility to the market and other services such as communication and extension (World Bank, 2008).

Existing literature indicate a symbiotic relationship between agricultural sector performance and road infrastructure, citing that such a relationship is very instrumental for rural poverty alleviation (Banjo et al., 2012). This study noted that returns on transport investment particularly in rural areas depends on various factors that include amounts of production, marketing and the related transport and processing needs, size of farms and their commercial orientation. This argument was reinforced by Hine and Bradbury (2016) in a case study of Central Kenya. Organized co-operatives provided accessible milk collection centres especially for farmers operating small -scale farms to the market.

It has also been established that transport is a major determinant of the consumer price of agricultural output. Were (2016) argued that reduction of transport costs because of good road network in Kenya, leads to reduced commodity prices for the benefit of consumers. On the

producer's side, poor transport network results into massive losses. For instance, it was estimated that between 30-40 per cent of agricultural output in Tanzania is stranded in farms because of inadequate road infrastructure (Lane-Visser et al., 2014). Conversely, Njenga et al., (2014) finds that cost of transporting perishable farm produce for a distance of two kilometres accounts for about 10- 20 per cent of net revenue accruing to farmers. Furthermore, transporting agricultural produce through conventional methods such as back loading, animal and motorcycle costs 16-30 times more than truck or lorry transport for a tonne kilometre. This implies that farmers stand to reap more benefits by enhanced road infrastructure.

A study by Gill and Kharas (2007) for the case of East Asia noted that the prosperity of agriculture as the main engine of economic growth of developing countries was largely explained by infrastructure. The study concluded that quality infrastructure such as roads, electricity and irrigation was key to both agriculture and agri-business enterprises. In support of these findings, the World Bank (2005) observed that lack of enough infrastructure seriously affects a country's competitiveness and hampers its efforts to fight against poverty and other economic challenges facing the developing world. The implication is that, majority of the developing countries are financially constrained and thus, have poorly-maintained irrigation systems, expensive electricity, and their rural roads are in sorry state which in turn have negative effects on agricultural production. However, this study had several limitations. First, the study employed survey data which cannot show changes/trend regarding production and infrastructural development over time as the current study does. Secondly, this study investigated agricultural production in general and not any crop in particular like the current study.

Studies have established a relationship between infrastructure development and economic growth. For example, Llanto (2007a) and Llanto (2007b) found a unidirectional causality running from

infrastructure to economic growth. In addition, the study noted that regional imbalances in economic growth are due to differences in infrastructural development. Similar findings were reported in Philippines (Llanto, 2008). Llanto finds that most developing countries have inadequate rural infrastructure such as roads, energy, telecommunication which ultimately translates into poor agricultural production, poor functioning markets, and poor global competitiveness of the domestic products.

Shamdasani (2016) investigated the role of improvement on roads on rural household's agricultural decision making for the case of India. The study employed difference-in-Difference framework on panel-level data. The results indicate that those households close to improved roads tend to diversify their crop portfolio than those that are way from improved roads. In addition, the study observed that accessibility to improved road infrastructure enables households to enhance utilization of complimentary inputs. Furthermore, Shamdasani reports that paved roads increases accessibility to the market, which imply a paradigm shift from subsistence to market-based agriculture. The study concluded that a big obstacle to investment in agriculture is poor road network in rural areas. However, Asher and Novosad (2016) conducted a similar study from which they find that development of roads in the rural areas, affected agricultural production negatively. Specifically, the study noted that due to improved roads, most people in the rural set up shift their labour from agriculture to wage labour. However, these results are limited in the sense that the authors used distance from the household to the nearest town as a proxy to rural road development as opposed to the distance from the house to the nearest road. This imply that their study was more focused on closeness to urban areas that road network development. The current study employed distance between household and the road which is believed to be a good measure for road network development than Asher and Novosad study.

A study conducted for the case in China on the effects of infrastructural development on agricultural production efficiency in rural areas has revealed that road infrastructure positively influences agricultural production (Zonghang & Xiaomin, 2009). The study noted that good roads reduces transportation costs, and makes it easy for the movement of both agricultural inputs and outputs. In addition, the study found that improvement of electricity, and water supply as well as their reliability increases agricultural technical efficiency. Furthermore, the study established that the structure of agricultural production and intensity of mechanization were other key infrastructural factors affecting agricultural production. This study had a limitation in the sense that it investigated how rural infrastructure development affects technical efficiency in agricultural production, meaning that it majorly focused on technical efficiency as opposed to production. In addition, Zonghang & Xiaomin, 2009) used survey data which could not present the trend of technical efficiency against infrastructural development. The current study investigated the effects of road, irrigation and electricity developed using panel data which is more advantageous than both time series or cross-sectional data.

In another study in China, Chen and Lin (2002) established that investing in irrigation, roads, and storage facilities, enhance production in the agricultural sector by reducing the costs and risks and on the other hand, increasing efficiency in production. The study held that development of infrastructure in the rural areas provides essential support for rural development. In a similar study, Peng (2002) had observed that construction of roads cuts down on agricultural production expenses. Fang et al. (2004) also investigated the impact of infrastructural development on agricultural production. The study found that the capability of the agricultural sector can be unlocked through investment in infrastructure in the rural regions.

Existing literature indicate that investment in infrastructure is key to accelerating agricultural production. According to Boopen (2006), road infrastructure is very critical in cutting down on production cost by reducing cost of transport. The study argues that road network makes it easy for essential interaction between farmers and the market as well as farmers and extension officers. Van de Walle, (2002) on the study of the link between road development and agricultural growth in Africa, noted that roads are extremely critical for the development of rural areas where agriculture is the main economic activity. This study concluded that poor transport system is a constraint across the entire continent and this largely explains the underdevelopment in rural areas. Similar sentiments were observed by World Bank (2005). Similarly, Gregory and Bumb (2008) opine that good roads enhances the possibility of profitable commerce which ultimately boosts investment in farming and hence more production. In addition, better roads in rural areas are found to improve returns in both farming and off-farming activities (Khachatryan et al, 2005).

Rud (2012) conducted an investigation into the effect of electricity access on agricultural production in India. Since the provision of electricity is not assigned exogenously, this study took advantage of the introduction of irrigation technology that was seen as an experiment. The study reported that use of irrigation in farming courtesy of expansion in electricity network led to more production.

2.4. Overview of Reviewed Literature

Empirical evidence suggests a positive relationship between investments in road construction and production in the agricultural sector. Studies argue that expansion of road network opens up rural areas where agriculture is the dominant economic activity. Nevertheless, there is dearth of literature on the impact of infrastructure on horticultural production. Most studies focus on crop production in general. In addition, literature has not established the effect of road, irrigation and

electricity development on horticulture farming in Kenya. Most previous studies have largely focussed on the effects of roads on agricultural development and ignored irrigation and electricity. Further, majority of these studies have used budgetary allocations on infrastructure as a measure of their development, as opposed to the actual development of roads, irrigation and electricity. The current study therefore, addressed these challenges by using more robust measures of infrastructure development, and focusing on horticulture production as opposed to agricultural production in general.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter explains the methodology followed in conducting the study. It covers theoretical framework, estimation model and description of variables. In addition, data type and sources are discussed, as well as the estimation method.

3.2 Theoretical framework

The study employed production function framework to examine the responsiveness of road, irrigation and electricity development on horticultural production in Kenya. This function explains the outcome of an economic activity through combination of various inputs. Production function provides the easiest way of determining production alternatives of a firm or an enterprise. According to Nicholson and Snyder (2008), this function expresses output Y, as a function of technically possible input combinations as:

$$Y = F(A, K, L) \dots\dots\dots (1)$$

In the equation (1) A measures technology, K is physical capital while L, is Labour.

Expressing Y in Cobb Douglas production function yields equation 2 as follows:

$$Y = AK^\alpha L^\beta \dots\dots\dots (2)$$

Equation (2) expresses Y (output) as a function of K, and L. the two production inputs, K and L are imperfect substitutes. For output Y to be produced, proportions of K and L are required. By direct incorporation of other determinants of production such as infrastructure (roads, electricity,

and irrigation), soil and farm size, yields the most commonly utilized Cobb Douglas production function in agricultural production.

To capture the responsiveness of horticultural production to infrastructural development, the study incorporated road, electricity and irrigation variables as in Nastis et al., (2012) and Lokesha and Mahesha, (2016), the augmented Cobb Douglas production function is expressed as:

$$Y = AK^\alpha L^\beta (Ifdev)^\rho (Z)^\sigma \dots\dots\dots (3)$$

In equation 3, horticultural output is Y(value in Kenya shillings), while K is physical capital (kshs) and L is labour (Kshs/hour).A is total factor productivity or technology. Ifdev refers to vector of infrastructure developments (road, electricity and irrigation), while Z is a vector of other variables such as, size of the farm under horticultural farming.

3.3 Analytical Model

The analytical strategy for this study was derived from equation 3 following the works of Nastis et al., (2012) and Kumar et al, (2016). These studies employ production function to measure agricultural output using different sets of inputs. Kumar et al. (2016) has used a Cobb-Douglas production to investigate how climate change affects agricultural production in India. Because the study is interested in the elasticities (the degree of responsiveness), equation 3 is transformed further by taking logarithm on both sides of the equation. The study included control variables in the estimation equation.

$$\ln Y_{it} = \beta_0 + \beta_1 A_{it-1} + \beta_2 \ln K_{it-1} + \beta_3 \ln L_{it-1} + \beta_4 \ln(hr)_{it-1} + \beta_5 \ln(lr)_{it-1} + \beta_6 \ln(el)_{it-1} + \beta_7 \ln(ir)_{it-1} + \beta_8 \ln(fs)_{it-1} + \varepsilon_{it} \dots\dots\dots (4)$$

Where Y_{it} is the value of output of household i at time, t , hr is the access to high quality road, lr represents access to low quality road, el refers to electricity access, ir refers to

irrigation, fs is the size of the farm under horticultural farming, ϵ is error term and β 's are parameters estimated (see Table 3.1).

The study incorporates the size of the farm under horticultural farming since it is likely to influence a farmer into horticulture. In addition, it is also believed to influence output of the farm. The study expects size of the farm to influence horticultural outcome positively. Furthermore, the study used labour (L) on the farm as well as assets to represent fixed capital (K).

Table 3.1: Variable Description, Measurement and Source

Variable	Description	Measure	Source
Y	Flowers, Fruits, Vegetables.	Value of output in Kshs (output in Kgs*Price)	Lokesha and Mahesha (2016), p.4
A	Technology (efficiency level)	$\frac{total\ input\ (value\ of\ L\ \&\ K)}{Total\ output\ (value\ of\ output)}$	Andersen and Shimokawa (2007), p.12
K	Physical capital	Total value of farm assets (in kshs)	Fan and Zhang (2004).
L	Farm labour	Daily wage rate per hour worked on farm	Dercon et al., (2007), p.8
hr	High quality paved road	Distance from farm to high-quality road (in Kms)-	Fan and Chan-Kang (2005), p. 29
lr	Low quality unpaved road	Distance from farm to low quality road in km.	Fan and Chan-Kang (2005), p.29
el	Electricity access	Dummy (1=Yes, 0=No)	Andersen and Shimokawa (2007), p.12
ir	Irrigation	Dummy (1=Yes=irrigates, 0=No)	Andersen and Shimokawa (2007), p.12
fs	Size of the farm under crop production	Number of hectares(ha)	Lokesha and Mahesha (2016), p.4

Source: Author, 2019

3.4 Data type and Sources

In this study, panel data from Tegemeo Institute for the period 2000, 2004, 2007 and 2010. The institute collects household survey data from across the country except Nairobi and the former North Eastern province region. The reason for exclusion of the two regions could be that they have little agricultural activities. While Nairobi is largely urban, North Eastern region is arid and semi-arid, and is also dominated by nomadism. These data mainly focus on households and agricultural activities like farm inputs, farm size, crop, prices and livestock production and horticulture farming.

Tegemeo institute collects this data with well-structured and standardized tools with the sponsorship of USAID. The institute used regional clusters to select households, majorly in rural Kenya. These clusters include: Eastern Lowlands, Western Transitional, High Potential maize zones, Western Highlands, Central Highlands and Marginal rain shadow zones. The total number of households surveyed in the four waves was 7,006 (1500, 1716, 1890, and 1900 for the years 2000, 2004, 2007, and 2010 respectfully).

3.5 Estimation Strategy

This study estimated the model (equation 4) using Pooled OLS following Soumya and Elumalai (2017). However Pooled OLS estimator suffers inherent weakness, that is, it does not control for selection bias. This is the reason why the study had to implement Fixed Effect (FE) and Random Effect (RE) estimators. These accounts for individual heterogeneity which is very critical (Wooldridge, 2006). Green (2008) noted that, combining time and cross-sectional data sets helps in overcoming unobserved factors like culture and different practices unique to individuals (e.g different farming practices by farmers in this case) which could impact on the estimates. It also controls for selection bias. Fixed effect (FE) model overcomes time invariant factors meaning that,

this model is not ideal to when investigating time invariant causes of the dependent variable. On the other hand, random effect (RE) assumes that variations across the phenomena under investigation are random and not interrelated with the explanatory variables in the model. RE model is therefore, ideal if the researcher has the assumption that time invariant factors can influence the dependent variable. However, the overall decision of whether to use FE or RE for the purpose of this study depended on the prediction of Hausman test (Green, 2008).

3.5.1 Diagnostic Tests

Hausman test

The study conducted this test to ascertain which model between FE and RE was suitable. Three steps were followed in this test. First, an FE estimation was carried out and the results stored using Stata command '*estimates store fe.*' Secondary, RE estimation was done and the results stored as well using Stata command '*estimates store re.*' Finally, Hausman test command '*Hausman fe re.*' This command hypothesizes that FE is the suitable estimation. The model checks for the correct specification or identification. The study tested the suitability of FE against RE. With Probability value of 0.0000 less than 0.05, the study concluded that FE model was ideal. Thus, the study presents estimates based on FE model.

Heteroskedasticity Test for FE

This is a challenge brought by differences in standard deviations across observations. This can bias estimates and thus, wrong conclusions. Unbiased results are achieved when there are constant variances across observations. The alternative hypothesis of the test is that all observations have constant variances. There is no heteroscedasticity if the hypothesis is accepted. Stata has a command '*xttest3*' for checking this challenge in FE estimations was carried out. With the

Prob>chi2 = 0.2330, this test imply that the estimation of FE did not suffer from heteroskedasticity.

CHAPTER FOUR

STUDY FINDINGS AND DISCUSSION

4.1 Introduction

This chapter presents results and discussion. There are two sections in this chapter. While section one analyses descriptive statistics, section two presents econometric results.

4.2 Descriptive Statistics

This section presents an analysis of descriptive statistics of all variable. They include: means and their standard deviations, as well as minimum and maximum values. The aim of descriptive statistics is to better understand the variables in anticipation of their relationship. Table 4.1 shows summary of these statistics.

Table 4.1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Value of produce(Y)	7,006	1766.203	37884.59	888	2572500
Access to Paved road (hr)	7,006	6.33051	7.482863	0	62
Access to Unpaved road (lr)	7,006	.6610634	1.268849	0	20
Technology (A)	7,006	22.09094	328.6402	.0004665	12500
Farm assets (K)	7,006	15570.9	82836.48	0	2000000
Hourly wage (L)	7,006	250.14	578.0124	100	640
Electricity Access (el)	7,006	.307652	.378996	0	2
Irrigation(ir)	7,006	.3455809	.4756045	0	2
farm size (fsize)	7,006	.1968873	1.212939	0	70

Source: Computed from Tegemeo, 2019

These statistics show that the mean value of harvest (Y) was Kshs.1,766.203 and it ranged between a maximum of Kshs. 2,572,500 and Kshs. 888.00, with a standard deviation

Kshs.37,884.59 throughout the period of study. This indicates that majority of the households surveyed practice small scale farming. Regarding roads, the results show that the distance between a household and the nearest paved road (hr) ranged between 0-62 KMs with a mean of 6.33 KMs, while that of unpaved roads (lr) oscillated between 0-20 KMs with 0.66 mean and a standard deviation of 1.2688. These statistics show that rural areas in Kenya are dominated by unpaved roads. Regarding technology, or efficiency in that matter, the mean was 22.09 with standard deviation of 328.6402. Concerning the value of farm assets, statistics show that the mean was Kshs. 15,570 while the maximum was Kshs. 2 Million with a standard deviation of Kshs. 82,836. Again, this reaffirms that small scale farming dominates horticultural production in Kenya.

Turning to labour (L), on average, each household paid Kshs. 250.14 per hour work on farm which ranged between a minimum of Kshs. 100 and a maximum of Kshs. 640. The mean of access to electricity (el) was 0.307652 while that of irrigation (ir) was 0.34558. These revelations indicate that, accessibility of electricity and irrigation facilities in the agricultural regions is lower. Lastly, the study indicates that the mean farm size (fs) under horticulture was 0.1968873 acres with a maximum of 70 acres and a standard deviation of 1.21 acres. This also indicates that most farmers in the Kenya's horticultural sector practice small scale farming.

4.3 Econometric Analysis

The aim of this study was to determine the responsiveness of horticultural production on infrastructural development focusing on Kenya. To do this, both FE and RE models were estimated. However, the overall decision of whether to use FE or RE lies in the prediction of Hausman test (Green, 2008). The results of the test of FE against RE are significant implying that the study favours FE model.

Hausman Test

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(6) &= (b-B)'[(V_b-V_B)^{-1}](b-B) \\ &= 84.44 \\ \text{Prob}>\text{chi2} &= 0.0000 \end{aligned}$$

If <0.05 (significant, use FE, otherwise use RE)

Table 4.2 presents summary results.

Table 2.2: Pooled OLS Estimation results of the effects of infrastructure on horticultural production

Value of output(Y)	Coefficient	
A	-.0001	(.00004)
hr	.0101***	(.00215)
lr	-.0379**	(.01249)
el	.0003	(.00224)
ir	.3065***	(.03113)
K	2.300	(1.7907)
L	-.0031*	(.00161)
fs	.1605***	(.01216)
_cons	25660***	(.02230)
Fixed-effects (within) regression	Number of obs	= 7,006
Group variable: hhid	Number of groups	= 1,450
R-sq:	Obs per group:	
within = 0.0753	min =	1
between = 0.0453	avg =	2.4
overall = 0.0622	max =	4
	F(8,2043)	= 20.81
	Prob > F	= 0.0000
corr (u_i, Xb) = -0.0739		
sigma_u .61269294		
sigma_e 1.0859451		
rho .2414614	(fraction of variance due to u_i)	

* p<0.10, ** p<0.05, *** p<0.010 Standard errors in brackets

Source: Author computed using Data from Tegemeo Institute,

4.4 Discussion

Findings indicate the paved roads are positively associated with horticultural production in Kenya.

In addition, the variable was found significant at 99% or 1% level of confidence. The size of the coefficient (0.0101) shown that a one KM construction of paved road, leads to about 1.03% increase in horticultural production. This means that the effect of paved roads on horticultural production is not

great. Paved/tarmac roads are quality and are an indicator of easier access to the market for seeds, and other input, market for produce, as well as information and extension services which is imperative for agricultural production. These findings are consistent with other several studies. For instance, Craig et al. (1997), Manasan and Chatterjee (2003), Fan and Zhang (2004) and Inoni and Omotur (2009) have indicated that transport infrastructure contributes significantly to agricultural productivity. For instance, Manasan and Chatterjee (2003) in their study, were able to establish in Greece that, 1 percent increase in road construction explained 0.38 percent increase in agricultural production. This imply that investment in paved roads in Kenya, has a greater impact on horticultural production as compared to Greece.

With regard to unpaved roads, the study established a significant, but a negative relationship with horticulture production in Kenya (-0.0379). In fact, a Km of unpaved road reduced horticultural production by about 3.78% in Kenya. This is a big adverse effect considering that a Km of paved roads increases production by only 1.03%. Unpaved roads are characterised with potholes, rugged terrain and other poor conditions which renders them impassable in some situations like during rainy seasons. In this case, they make movement of people, goods and services quite difficult and they can also make information access a tedious process to the farmers. This could thus mean that, the presence of these roads hampers horticultural production due to poor access to both goods and factor markets. Similar arguments were made by Thorat and Fan (2007).

In addition, findings indicate that electricity and horticultural production are positively associated. however, this variable is not statistically significant. Contrary to these findings, other studies, for instance, Manasan & Chatterjee, 2003 and Dercon et al. (2007) for the Indian case, argue that

investment in irrigation, electricity and roads has a positive implication on both on-farm and non-farm productivity.

The study has also found irrigation positively influences horticultural production in Kenya. This variable is also highly significant given its p-value of less than 1%. Unlike, a paved road, the effect of irrigation on horticulture is quite huge. The coefficient (0.3065) of this variable indicates that farmers who irrigate their farms can increase their production by about 30.65%. With irrigation, farmers are able to engage in farming activities all throughout the year, and hence the huge impact of irrigation to horticultural production. Similarly, Craig et al. (1997), Thorat and Fan (2007) concluded that irrigation and transport deficiencies weaken huge prospects of the agricultural sector in the least developed countries.

Furthermore, findings indicate that farm size and production of horticultural crops are positively, and significantly related. The coefficient of farm size (0.1605) show that 1 acre increase in the land under horticultural farming leads to about 16.50% increase in the value of produce. This means that there is an increasing return to scale in this sub-sector with regard to farm size.

Concerning labour, the study has found a negative effect on horticultural production (-0.0031). The variable was measured by hourly wage rate on the farm. This variable is also significant at 10% level. The negative relationship is could be attributed to diminishing marginal productivity of labour on the horticultural farms. In terms of the impact, an increase in one Kshs. of wage, reduces the value of horticultural production by about 0.3%. Finally, the study did not establish any significant relationship between physical capital (farm assets), technology and horticulture production.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes study findings based on the formulated objectives. In addition, conclusions and policy recommendations are presented.

5.2 Summary

The general objective of this study was to investigate the responsiveness of horticultural production to infrastructural development in Kenya. Specific objectives were: to determine the responsiveness of horticultural production to increase in number of kilometers of paved roads, to determine the responsiveness of horticultural production to irrigation investment and to determine the responsiveness of horticultural production to electricity access expansion in Kenya. The study employed a panel data approach using data from Tegemeo Institute for the years 2000, 2004, 2007 and 2010. The value of total harvest for horticultural crops (flowers, vegetables, and fruits) was the dependent variable, while both paved and unpaved roads, electricity and irrigation were the study's independent variable. In addition, the study incorporated other control variables which included: physical capital, labour and farm size. The study employed a Fixed effect model to estimate results.

The study finds that an increase in the number of paved road network is positively related to the value of horticultural output. Specifically, the estimated results show that a one-kilometer increase in paved road leads to a 1.03% increase in horticultural production in Kenya. These findings are consistent with the commonly held knowledge that good roads enhance production in the agricultural sector (Andersen & Shimokawa, 2007; Thorat & Fan (2007). This is because, smoother/paved roads have been found to facilitate faster movement of people, goods and services.

Since most horticultural products are highly perishable, good roads can encourage production by reducing the distance between the farm and the market. In addition, a good transport system reduces the cost of transport and hence encouraging production due to reduced costs of production. In contrast, the study has established negative link between unpaved roads and horticultural production. The variable was found to be significant at 5 percent. This could be explained by the poor condition of most unpaved roads in most part of Kenya, which make it very difficult for goods to move to the market, and hence, increase post-harvest losses. This serves as a discouragement in the production of the highly perishable horticultural products.

The study has established that irrigation is positively related to horticultural production in Kenya. This variable was also found to be significant at 1% confidence level. Irrigation ensures planting of crops in season and out of season. In addition, horticultural crops require regulated amount of rainfall which is only possible with irrigation. Thus, irrigation serves as an encouragement to farmers and hence increased production.

Furthermore, the study has revealed that farm size influences horticultural farming positively. Large farm sizes are expected to result into more horticultural products. With regard to labour, findings reveal a negative relationship with horticultural production. This was attributed to diminishing marginal productivity. Finally, the study finds no statistical relationship between farm assets (physical capital) and horticultural production.

5.3 Conclusion

From summary, interpretation and the foregoing summaries, the study can make several conclusions. First; paved roads encourage horticultural production in Kenya. Nevertheless, unpaved roads discourage horticultural production. Secondly, the study concludes that electricity

has a positive implication on horticultural production in Kenya. Third, irrigation farming is very instrumental when it comes to horticultural farming.

5.4 Recommendations

Horticultural farming contributes immensely to the Kenya's growth and development. Apart from provision of food, foreign exchange earnings through exports and promotion of trade, this sector creates more job opportunities. Thus, the two levels of government need to devote a lot of their efforts to revitalize which appears not to perform well in the current times. In particular, the government should focus on increasing the number of paved roads especially in rural areas where horticulture farming takes place. In addition, investment in and encouragement of irrigation farming will be necessary.

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