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# The Influence of agricultural innovative strategies on banana productivity among smallholder farmers in Kirinyaga County, Kenya

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# THE INFLUENCE OF AGRICULTURAL INNOVATIVE STRATEGIES ON BANANA PRODUCTIVITY AMONG SMALLHOLDER FARMERS IN KIRINYAGA COUNTY, KENYA

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## DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the thesis itself.

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# ABSTRACT

Increasing agricultural productivity is now a popular subject across nations as a result of increasing population and an increase in demand for food. Consequently, there is an urgency to adopt modern agricultural technologies which will affect the growth of agricultural output, especially among smallholder farmers. The adoption of innovative strategies to help boost banana production is still low and they are not readily visible in most smallholder farms. The study looked at key innovation strategies that influence banana productivity. Key focus being, water management strategies, soil management strategies, and banana plant management strategies and how they affect banana productivity. The study was underpinned by the theory of Diffusion of Innovation. A descriptive research design was applied in the study. Respondents were smallholder banana farmers drawn from three constituencies in Kirinyaga County namely, Kirinyaga Central, Ndia, and Gichugu. The study found that the level of innovative strategies in water management, plant management, and soil testing practices was low. On soil management strategies the study found out that soil testing practices are poor and hardly practiced by the farmers. Other soil management practices such as Mulching and, Intercropping had a significant influence to productivity while fertilizer did not significantly influence productivity. In the case of plant management, a very small percentage of farmers source their seeds from authorized dealers, they mainly recycle the tubers from their farms and neighbors. The study also found out that water management practices such as furrow technique and pumping had significant influence on productivity. Social economic factors such as being trained on banana farming and years of study had significant influence on productivity. Hence, a conclusion was made that farmers who adopt innovative strategies were likely to influence the overall productivity in their farms more so if the strategies are all adopted at once.

## *DEDICATION*

I dedicate this work to my husband Muriithi, my children and my nieces Ceci big and Carol, for supporting me emotionally, psychologically, and financially through the course of this study. Thank you for your patience and words of encouragement.

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **TC** | Tissue Culture |
| **IPM** | Integrated Pest Management |
| **WB** | World Bank |
| **SOM** | Soil Organic Matter |
| **ISFM** | Integrated Soil Fertility Management |
| **CBI** | Coffee Banana Intercropping |
| **IITA** | International Institute of Tropical Agriculture |
| **SPSS** | Statistical Package for Social Sciences |

## DEFINITION OF TERMS

**Agricultural Innovation strategies**: New or improved ideas, technology, knowledge, and infrastructure in agricultural practices.

**Agricultural productivity**: Agricultural Productivity is the measure of the ratio of agricultural outputs to agricultural inputs.

**Smallholder farmer:** Farmers whose farmland is less than 6 acres.

**Agricultural transformation**: The process of improving farming practices to aid in high productivity

**Integrated Pest Management:** It is a combination of biological, cultural, and habitat control practices to prevent and control pests.

**Integrated Soil Fertility Management** is a set of agricultural practices adapted to improve both soil quality and the efficiency of fertilizers and other agro-inputs.

**Extension service**: Extension service refers to technical support, the information offered to farmers on agricultural practices and technology.

**Mulching**: Application of organic layer of material applied to the soil.

**Intercropping**: The practice of growing more than two crops at the same time on the same piece of land

**Tissue culture bananas:** Cloned and micro-propagation of banana tissues.

**Soil management:** Soil management is the practice of treating and protecting soil to retain its nutrients and improve its functions

**Water management:** The control and movement of water through distributing and harvesting.

**Banana Plant management:** Agricultural practices use to improve the growth, development, and yield of the banana crop.

**Social-economic factors:** Society and economic-related factors that affect the adoption of innovation strategies.

# CHAPTER ONE: INTRODUCTION

## 1.1: Introduction of the study

The chapter provides the background of the study, status, operational definition of the study variables, that is, Innovative Strategies and Productivity, followed by an overview of general banana production in Kenya. The chapter then provides the research objectives, scope and significance of the study as well as the contribution of the research study to practice and theory.

### 1.1.2: Background of the study

Innovation and reinvention progress are transforming various economies at a faster rate; agriculture and food production are no exception (Weyori et.al., 2018). Food Security and world population growth drive the necessity for the intensification of food production (Mottaleb 2018). For most underdeveloped and developing countries, new agricultural innovations not only ensure food provisions but also serves as an important factor in the pursuit of sustainable growth (World Bank, 2018). Since the first-wave green revolution in alleviating the food security problem for the rural population, innovation in agriculture has been an important research topic in agricultural economics.

Agricultural development and innovation balance each other. Innovation is defined as the successful application of knowledge with social and economic significance(van der Veen 2010). Innovation as a process and outcome is crucial for development (World Bank, 2018). Smallholder farmers are key in allowing for the development of farming systems and practices that improve general banana yields (Ullah et.al., 2018). Agricultural transformation is considered effective if it is centered on small-scale farmers as most of them are poor and have limited resource capabilities compared to medium and large scale farmers (Otchia 2014). Creating more strategic approaches in the implementation of technologies that can boost the productivity of the banana crop is crucial in promoting sustainable and intensification farming systems in banana farming that will alleviate food security problems, increase employment and uplift the living standards of smallholder farmers (Nyombi 2013).

Future productivity gains in banana farming and agriculture as a whole need to save not only land but a wider array of natural resources such as water and soil so as to avoid negative impact on the environment as well as serve the needs of the vulnerable populations (Ouma, 2009). Blazy et al.

(2009) states that the technical innovations in agriculture are the basis of progress in conventional agriculture that will save the environment from harmful agricultural practices, these practices include; genetic innovations such as pest-resistant varieties, intercropping, integrated pest management, a new type of fertilization, or new crop rotations. Additionally, innovations provide different economic and ecological services, e.g., increased yield, reduced pesticide uses, and protection against erosion and runoff (van der Veen 2010).

### 1.1.3: Innovative Strategies by Smallholder Farmers.

Blazy et al., (2009) study focused on Guadeloupe, a country that continues to make impressive strides in as far as investing in agricultural technologies is concerned. According to (Blazy et al. 2009), farmers are inundated with advertisements that explore various innovations whose producers claim can increase crop yields or reduce environmental impact. Investment in technological innovations contributes to increasing yields, especially in countries that experience rapid population growth and keen to enhance food security (Mwangi and Kariuki 2015). Some of the innovations adopted by smallholder farmers quoted by (Mwangi & Kariuki; van Asten et al., (2015);Petry et al., (2019) and Karienye et al., 2020) include; crop rotations, regulated use of pesticides, intercropping, use of resistant cultivars, integrated systems, and the conditional use of pesticides.

In a study carried out in Northwest Tanzania on ‘Options for sustaining farm productivity in the banana based farming system’, application of residues of herbaceous legumes was found out to double or triple the yield of the other crop contributed to yield increase (Mwijage et.al., 2016). This soil management practice contributes to sustainable productivity in the long run. In an age where the global community is concerned about climate change and its effects on agricultural production, innovation around soil management is the only way that banana farmers or farmers of other food crops can find the trade-offs between inputs and yields as well as address both the environment and production concerns in banana farming based on empirical research carried out in Congo (Otchia 2014).

Agricultural water management strategies contribute to poverty reduction through, improving productivity, creating employment opportunities, and alleviate income challenges among smallholder farmers (Biazin et al. 2012). This is achieved through consumption, utilization of other yield-enhancing inputs and diversification into high-value products (Ouma 2009).

Overreliance on rain-fed agriculture is a major challenge to most farmers in Africa. According to a research done by Burney et.al., (2013), sub-Saharan Africa has only 4% of agricultural land irrigated with a comparison of an estimated 40 million ha suitable for irrigation. The research further reports that the impact of agricultural water management for Sub-Saharan Africa on poverty reduction increase where irrigation is practiced compared to those who rely on rain for agriculture, citing that agricultural water management, rural infrastructure, and policies are the pathways to breach the poverty gap in Sub-Saharan African agriculture. A synopsis of the existing and future water conditions among smallholder farmers indicates that it is crucial to establish cost-effective methods to boost water productivity by implementing the best approaches that are efficient and sustainable (Hillel 2005). Additionally, planting alternative crops that can make best use of irrigation practices to aid in improving agricultural water management would be the key factors in balancing between farming and the water resources available (Nyamadzawo et.al., 2013).

The Food and Agricultural Organization (FAO, 2015) finds innovative irrigation growing in Kenya, but not at its optimal growth rate. FAO reports that expanding agricultural farms under irrigation is one of the country's focal points in its ambitious Vision 2030. Currently, vast banana-growing areas depend on rainwater. FAO notes Kenya has the potential to adopt modern irrigation systems, considering that it is a water-scarce country where farmers and households experience high competition over the country's scarce water resources.

In addition to the scarce water resources, the current considerations for production systems that accommodate for environmental systems require that Kenya engages in significant water-saving strategies. Hence, FAO recommends that irrigation technology such as pressurized drip and sprinkler irrigation potentially offer a solution to the inadequate water resources available to banana farmers. These irrigation methods are referred to as distributed Irrigation systems and are privately owned by individuals or groups (Burney et al. 2013), 'they are systems which the water access (via pump or human power), distribution (via furrow, watering can, sprinkler, drip lines, etc.), and use all occur at or near the same location'.

In Uganda (Nasirumbi et al. 2017) consider the aspect of technology uptake in banana production as among the major challenges that Uganda faces in its banana-growing sub-sector. The author suggests an increase of agricultural innovations systems where they analyze the interplay between the recently released hybrid bananas varieties introduced in Uganda and the innovative processes implemented to improve yields in order to improve production. Fahad et al., (2017) highlighted the importance of developing climate-smart seed varieties and disease resistance with tolerance to drought and heat stresses to produce more food in developing countries.

### 1.1.4 Banana Production in Kenya

Banana is a popular food, and it is considered to contain very high chemical composition, high contents of vitamin and minerals (Kasyoka et al. 2011) essential to contribute to that enables food and income security. According to Kamira et al., (2016) worldwide banana is a universal fruit cultivated in tropical countries for its valuable applications in the food industry. The crop is ranked fourth after rice, wheat, and maize as the world's most valuable crop consumed for their high nutritive and therapeutic values (UNICEF 2018). It is also common for it beneficial applications in the food industry as an excellent source of various useful raw materials for other industries that can be tapped through recycling of the agriculture waste of the plant (Padam et al., 2014).

Based on a research done on the Role of Tissue culture Bananas in Kenya by Mbaka, Mwangi, & Mwangi (2008), in East Africa (Kenya, Uganda, Tanzania, Rwanda, Burundi and the Democratic Republic of Congo), banana occupies 30% of the cultivated land, the main banana cultivars grown are the East African Highland Bananas (EAHB-AAA), the brewing types (AB, ABB), the cooking types (ABB), and the desert types like the 'Gros Michel' and 'Kampala' (AAA, AAB). They further state that about 20 million people in East and Central Africa depend on bananas for food and income. Bananas are also considered to be environmentally sustainable crops as they provide surface cover and reduce soil erosion. Leading producers in Kenya according to a report done by (Kilimo Trust 2012) include: Meru (19 percent); Kirinyaga (14%); Embu (12%); TaitaTaveta (9%); Muranga (7%); Kisii (6%); TharakaNithi (6 %); Bungoma (5%).

Mbaka et al., (2008) states that banana production in Kenya is a profitable agricultural practice which can alleviate poverty, hunger for small farmers. However, statistics show the yields per acre in most banana-growing countries including Kenya fall significantly behind the capacity required in tropical areas attributed to factors such as low input levels and pest infections (Kabunga, Dubois, and Qaim 2012). Losses of yield highly impact the cost of growing bananas and end up being high-priced for consumers. Thus, the adaptation of more innovative strategies such as the biotechnology (tissue culture), integrated pest management (IPM), and research on higher yield banana varieties conducive for each region growing the product (Wasala 2014) that can enhance productivity, pest, and disease controls should be implemented. Muyanga (2009) lists the constraints in banana farming in Kenya and East Africa as follows; high costs of clean planting material, lack of appropriate and quality farming inputs, high post-harvest losses, and prevalence of pests and diseases.

Soil nutrients depletion is a major challenge facing most smallholder farmers in Africa (Vanlauwe et al. 2015). Research has shown there is a high rate of nutrient removal from the banana plantations, despite the often high volume of organic materials applied (Bekunda et al. 2002) thus need to carry more research on innovative ideas that can help improve soil nutrients and educate farmers more on soil management. Soil management is an important attribute to crop productivity as it ensures that minerals do not deficient or become toxic to plants and that appropriate minerals elements enter the food chain(White et al. 2012). Other strategies such as intercropping, mulching and minimum tillage are also considered as environmental friendly strategies, easy and cheap methods that can help smallholder banana farmers improve their productivity. Intercrop of legume and non-legume crop and trees contributes to nitrogen fixation, improved water retention, reduced crop failures to drought, pest and diseases. Leaves of trees intercrop are used as mulch and compost, thus contributing to above ground carbon sequestration (Nyasimi et al. 2017).

Water management is also a key production strategy as water quantity and distribution plays a significant role in determining the productivity of crops and the outcome of many host-pathogen interactions in natural plant populations. The potential for bananas to produce year round is best expressed when water is abundant and daily temperatures are in the range of 20-30°C (Bergh et al. 2010). Water management strategies such as irrigation and water conservation techniques have resulted in better production when implemented by banana farmers. Small-scale irrigation offers key opportunities for adaptation as water supplies dwindle and rainfall becomes more erratic. Through irrigation, farmers can diversify into high value vegetable production thus reducing risks of crops loss and increasing incomes (Nyasimi et al. 2017).

Banana plant management is also key in increasing productivity. In a research carried out by Bellamy (2013) on the variations in banana production practices in Costa Rica identified Tissue Culture banana as alternative cultivars systems that combine high productivity and profitability, with reduced reliance on agrochemicals. Traditional propagation technique of using suckers directly detached from a mother plant which is commonly used by smallholder farmers is limited by low multiplication rates and it is more prone to pests and diseases, which culminates in reduced banana productivity, improved propagation techniques such as tissue culture stands out as the most prolific method of delivering high quantity and quality seed in banana (Tumuhimbise and Talengera 2018).

Besides being an edible fruit, bananas are grown for other purposes that have become interlinked with the social-cultural and livelihood benefits of human society (Ravi, 2013). Furthermore, the socio-economic dynamics within smallholder farmers affecting the implementation of new agricultural innovations that come along with the development of this fruit crop has fallen short of being addressed (MMurongo et al. 2018).

Karienye et al.,(2020) in a study on 'the socioeconomic factors influencing farmers' choice of adaptation strategy to climate change', recognized that irrigation and shifting planting dates were the most preferred adaptation strategies among small holder's banana framers. The study further highlighted attributes such as the size of land under banana production, age of the household head, access to extension services, access to financial facilities, agro-ecological zone setting and perception of climate change were significant in explaining the farmers' adaption of irrigation as a strategy.

## 1.2 Problem Statement

Declining rate of agricultural performance is a concern in Kenya. Over the years, contribution of the sector to the Gross Domestic Product (GDP) has been declining from 40% in 1963, 33% in 1980s to 31.5% in 2017 (KNBS, 2018). World Bank (2013) also reported that Africa's agribusiness and agriculture are and falling short of their potential. Despite the efforts made by the Ministry of Agriculture and development organizations, agricultural potential of the country has still not been exploited to the full.

Full exploitation of agriculture has largely in part been hindered by slow implementation of good policies, especially around innovation and sustainable strategies for smallholder farmers (World Bank 2018). This problem has negatively impacted agriculture among small holder farmers who constitute the majority. This has implications resulting in unemployment, income inequality and food insecurity for the country (World Bank, 2016). This calls for measures to increase agricultural productivity in the sector to help uplift many rural households out of poverty (World Bank, 2019; GoK, 2019b).

Banana farming is gaining popularity in Kenya, one because of its contribution to food security based on its nutrients and secondly due to its ease of production in suitable climate. This calls for more important considerable measures to promote best and innovative strategies that can help farms get promising yields (Makini et al., 2017) especially in areas where banana growing is promising, Kirinyaga being one of the key areas. Besides banana being on-demand in Kirinyaga County, there are gaps in data gathered on innovative strategies commonly used by farmers and their influence on productivity.

This study therefore is keen on identifying innovative strategies being practices by banana farmers and how they influence productivity with the intention to contribute to informed recommendations applied across the agricultural sector in the country.

## 1.3. General Objective

The general objective of the study was to investigate the effects of agricultural innovative strategies on enhancing banana productivity among smallholder banana farmers in Kirinyaga County in Kenya.

### 1.3.1. Specific Objectives

The specific objectives of the study were:

1. To examine the influence of soil management strategies on banana productivity.
2. To investigate the influence of water management strategies on banana productivity.
3. To study the influence of banana plant management strategies on productivity.
4. To identify the major socio-economic factors hindering banana productivity among smallholder banana farmers in Kirinyaga.

## 1.4. Research questions

The study will address the following questions:

1. What are the effects of soil management strategies on banana productivity?
2. What are the effects of water management strategies on banana productivity?
3. What are the effects of banana plant management strategies on productivity?
4. What are the major socio-economic factors hindering banana productivity among smallholder banana farmers in Kirinyaga?

### 1.5. Scope of the study

This study will focus on investigating the influence of the innovative strategies on banana productivity among smallholder farmers in Kirinyaga County focusing on three constituencies namely: Kirinyaga Central, Ndia, and Gichugu.

In Kirinyaga most farmers choose to farm banana due to its suitability for production in the area, high demand in the market, and relative ease of crop management (Mbaka et al., 2008). The three Counties are where many smallholder farmers growing banana as a monocrop and others are intercropping with coffee and tea are located.

The areas will give a good comparison when it comes to productivity and general innovative strategies such soil management, water management and banana plant management underpinning the study on the theory of diffusion of innovation.

### 1.6. Significance of the study

The adoption of innovative strategies to help boost banana production is still low in the study area as they are not readily visible in most smallholder farms. The study results would be beneficial to the farmers, the development partners, policy makers and to further scholars.

The study findings will benefit farmers in understanding the existing innovative strategies and how it can aid them to increase productivity of bananas and other. It will enable them to identify weaknesses and areas to improve by examine the innovative strategies being implemented on their farms.



The study will also benefit potential agricultural development investors, developers and donors in identifying innovative strategies that can improve agricultural production among smallholder farmers. It is important for the developers and donors to identify the innovative strategies in order to aid in closing the innovation implementation gap of agricultural strategies for smallholder farmers.

Policy makers in the agricultural sector will gain more ideas on how to mitigate food insecurity as well as increase incomes of the banana framers through an increase in banana production and eventually contribute to the country’s economy. This will enable the government, as a policy maker to initiate reform for capacity innovative strategies in the agriculture sector. It will also help policymakers come up with proper frameworks to put into practice innovative strategies across the entire agricultural sector as well as help intensify the success of banana production, value addition and marketing strategies that are lacking.

Scholars many also find the study findings useful in carrying out further research around the study area of Innovative agricultural strategies that influence productivity

# CHAPTER TWO: LITERATURE REVIEW

## 2.0 Introduction

This section contains the literature review of the vital aspect of the study. It will cover i) the theoretical summary ii) an empirical review of literature related to innovative strategies in banana farming iii) A summary of the findings from existing literature and identification of research gaps at the end of the review.

## 2.1 Theoretical Review

The study was anchored on the diffusion of innovation theory.

### 2.1.1 Diffusion of Innovation Theory

The Diffusion of Innovation theory is often referred to as the change model for directing technological innovation where the innovation itself is modified and presented in ways that meet the needs across all levels of adopters (Fagerberg et al., 2017). Rogers & Adhikarya (1979) described the innovation-decision process as "an information-seeking and information-processing activity achieved through five levels namely; sharing of knowledge, persuasion or influence from different bodies, decision making, implementation, and confirmation.

The diffusion and adoption of agricultural innovation have been a central determinant of agriculture development. Innovation is normally associated with new ideas and existing knowledge and resources (Fagerberg et al., 2017). In agriculture, innovations are mainly related to increasing productivity, improving the quality inputs, new farming practices, and techniques on improving processes(van der Veen 2010).

The theory also further explains the relationship between technological innovation and social relations as a crucial determinant of what farmers want to see and hear. The rapid – changing technologies in agriculture tend to influence small – scale farmers who struggle to understand the new farming practices in comparison to traditional practices. Despite the confusion and difficulties in accepting new ways of agricultural practices, Petry et al., (2019) confirms there is a strong correlation between innovation and increased agricultural production.

The success of diffusion of innovation for agricultural development lies on effective dissemination of technical knowledge and identifying gaps and differences in productivity among farmers (Lukuyu et al.,2012; Petry et al.,2019; Bandiera & Rasul 2006; van der Veen, 2010). Studies show that farmers are willing to learn more and even adopt new farming strategies after the new ideas have been tested by their neighbors, friends, or family members (Petry et al. 2019). In a study by Bandiera & Rasul (2006) on ‘Social networks and the Adoption of New Technology in Northern Mozambique’ found out that farmers’ decisions to adopt new crops are based on the choices of their network and family, the study further states that the adoption decision of farmers who are informed are hardly influenced by the decisions of other.

Researchers have also observed that the adoption of innovations in agriculture has tremendous benefits such as an increase in productivity mainly through the waste reduction and use of new strategies (Lukuyu et al., 2012; Bandiera & Rasul 2006). To the smallholder farmer, diffusion is a kind of social change. It is defined as the process by which alteration occurs in the structure and function of a social system. Diffusion of an innovation thus leads to social change. Through increase of productivity it will ultimately led to improved standard of living among farming community.

Diffusion of Innovative strategies on soil, water and plant management require several years of experiments, trials, repetitions and validations in a given area in order to influence productivity (Rajinder Peshin 2009). It requires a clear understanding about the tactics which may vary from area to area. With the coordination of key stakeholders, it needs a planned strategy of imparting knowledge and skill and active learning and active adoption by the farmers.

The diffusion of agricultural strategies under this study that is; soil management, water management and plant management have not been fully diffused to farmers as should be. Diffusing these strategies requires educating the farmers for its adoption and it must deal with farmers’ needs, perceptions, constraints, objectives and its complexity demands. The theory emphasizes the implementation of innovative strategies by stakeholders in leveraging and deployment of knowledge and skills based on the uniqueness of an area.

The theory will be significant for the study to understand whether existence knowledge and capabilities in implementing innovation strategies on soil, water and banana plant management influence the overall farm productivity. It will also aid in understanding why some strategies are adopted and other are not as well as give a general overview of the impact of different stakeholders in innovation adoption.

### 2.2: Empirical Review.

In this subsection, the focus is to establish the empirical basis of the relationship between key variables.

#### 2.2.1: Soil Management Strategies

The issue of failed soil in Africa's small-scale farmers is alarming as most farmers have extracted large quantities of nutrients from their soils without returning them in sufficient quantities as manure or fertilizer (Sanchez and Swaminathan 2005). White et al., (2012) empirical findings showed massive losses of soil nutrients following deforestation in the northeastern hill region of India that adopted shifting cultivation practices. However, they noted that the adoption of appropriate agroforestry systems can reduce soil losses, increase soil organic matter (SOM), improve soil physical properties, and preserve water resources. In addition, techniques such as zero or minimum tillage, mulching, cultivating cover crops, and hedgerow intercropping can be used to increase SOM and sustain soil health (Mwijage et al. 2016).

Coupled with the aforementioned recommendation to improve soil organic matter, the newest farming input considered to help farmers gather information on the nutrient status of their farm soils and have appropriate recommendations on how to improve the soil quality is soil testing (Kokoye et al. 2018). Soil testing services to farmers have recently emerged in developing countries as a means to improve soil quality with the prospect of increasing agricultural productivity (Kokoye et al. 2018). As a result, researchers are innovating new ways that can help farmers replenish soil fertility key innovation being the Integrated Soil Fertility Management (ISM) with includes both soil testing and fertilizer use (Mwijage et al., 2016; Sanchez & Swaminathan, 2005; Bekunda et al., 2002). ISM technology has been tested and is regarded as a means to increase crop productivity and at the same contribute to environmental sustainability (Bekunda et al. 2002). Vanlauwe et al., (2015) highlights the benefits of typical ISFM interventions as including the combined use of organic manure and mineral fertilizers.

The inorganic fertilizers are usually expensive for the low income and small scale farmers' yet organic manure can be used as an alternative (Addis 2019). Organic fertilizer in their view should substitute the inorganic fertilizer used on most banana farms to maintain environmental quality. further states that the nutrients contained in organic manures are retained longer in the soil by activating the soil microbial mass that eventually leads to higher yields compared to inorganic fertilizers.

These observations create the platform to infuse new innovative practices in the production and use of organic manure to increase yields in banana production. According to (Bellamy 2013b) innovative banana-growing systems in Costa Rica use organic fertilizer with a system of small farm sizes, high productivity, and extensive mix with different tree species. The innovation here is that the crops are grown together with bananas in farms where farmers use organic fertilizer.

The loss of topsoil, either through mineral imbalance or erosion, is the single largest threat to agricultural productivity (Pretty and Bharucha 2014). Soil erosions by wind and water are the main processes by which topsoil is lost (Kokoye et al. 2018) which can be conserved through minimum tillage, intercropping, and mulching (Muthee et.al.,2019).

Intercropping provides an important means of raising productivity and land-use efficiency of smallholder farmers in Kenya (Ouma & Jagwe, 2010) among other benefits such as improving soil fertility and managing pests (Wachira et al. 2013), it also minimizes farm risks.  It is also an effective use of available resources,  provides efficient use of labor, controls soil erosion, and food security(van Asten et al. 2015).  Intercropping also contributes to the overall management of farm inputs resulting in sustainable practice achieved through the restoration of natural resources if practiced for a long time( Ouma, 2009). Rodrigo et al., (2005) evaluated the benefit of intercropping banana and rubber in India with the increase in productivity and the results  were positive.  The research found out intercropping increased the growth of both rubber and banana components suggesting that the relationship associated with the closely packed intercrop cover, controlled the microclimate and helped both plants rely on each other for support during harsh weather conditions which reduced the plants stress to survive.

Additional in a research carried out by the International Institute of Tropical Agriculture (IITA) (2015) in East and Central Africa has confirmed that coffee- banana intercropping (CBI) is a perfect model for smallholder farmers as it helps in soil fertility, provision of in situ mulch, food security reduced pest and diseases as well as manages the natural resources around the farm. The research further states that CBI is more effective resource use in land-constrained farms and farmers benefit more if they correctly space the plants to manage resource competition and at the same time focus on improving the overall yields of bananas and coffee crops.

Muthee et.al., (2019) analyzed banana production practices in Embu,  he established that intercropping is a common practice in the region where banana crops were mixed with other crops and agroforestry trees, citing that those who practice intercropping benefited from high yields. Ouma, (2009) reported that intercropping is mainly practices in East Africa due to reducing land sizes and the need to provide food security. Wachira *et al.* (2013) argued that intercropping is also favored if one of the crops (e.g. French beans) is consumed and the other one (e.g. banana) is used as a cash crop, as it is the case in Kirinyaga County.

### 2.2.2 Water Management Strategies

According to Nyombi (2013), bananas require 25mm of rainfall per week for satisfactory growth, which corresponds to 1300mm per year. To achieve good yields, bananas should consistently receive 200 to 220mm of water per month (Fandika et al. 2014), hence the need for irrigation strategies and other water harvesting initiatives to supplement rainwater.

Water management strategies such as improved water harvesting techniques, drip irrigation, and soil nutrient management need to be implemented and promoted to enhance sustainable food among smallholder farmers as identified in South Asia (Raza et al. 2019). Water harvesting and irrigation strategies are considered to have been determinant for some major successes in Costa Rica Banana production (Bellamy 2013) and improvement of rice production in the Philippines (Villano et al. 2015).

Lee, Gereffi, & Beauvais, (2012) states that adaptation of irrigation strategies such us furrow, sprinkle method can sway household agricultural production and income generation by fostering year round production. Fandika et al. (2014) study investigated the benefits of drip irrigation on banana yield among smallholder farmers in Malawi, the results showed that average yields and gross margin increased linearly with increasing amounts of applied water. A study that was done by Nyombi (2013) in Uganda confirmed that only a small fraction of banana farmers practice irrigation stressing that failure to give enough moisture to bananas affects yields.

Drip irrigation is considered an efficient irrigation mechanism for utilizing the available water effectively for maximum crop production as it delivers water and nutrients to the root zone of plants (Pawar et.al.,2017). In a study carried out by Kulecho & Weatherhead (2006) on ‘Adoption and experience of low-cost drip irrigation in Kenya’ found out several factors determine whether small-holder farmers will adopt the irrigation mechanisms such as access to developed irrigation, water resources, efficient marketing facilities, efficient technical and institutional support and security for the kits. In an empirical study carried out by Woniala and Nyombi (2014) in Uganda, respondents were selected based on several operational irrigation schemes in each of the four sub-counties, only13% and 12%of the respondents were found to be practicing irrigation and weeding their orchards respectively. Failure to practice irrigation implies that moisture stress affects the yields.

According to Hillel, (2005)‘water harvesting’ is the collection of rainstorm-generated from a catchment area to provide water for use or irrigation. Water harvesting techniques help farmers improve crop yield necessitating the need to investigate the options of increasing water productivity in rain-fed agriculture for increased food production (Nyamadzawo et al. 2013). Rainwater harvesting techniques have a significant capability for improving rainwater-use efficiency and sustaining rained agriculture, the main technologies being practiced by smallholder farmers being micro-catchment and *in situ* rainwater harvesting (Biazin et al. 2012).

Water harvesting using *in situ* techniques constitutes a simpler, more affordable, and adaptable technology for resource-poor smallholder (Mudatenguha et al. 2014). *In situ* water harvesting techniques increase the amount of water stored in the soil profile by trapping or holding rainwater where it falls, it involves small movements of rainwater as surface runoff, to concentrate the water where it is required in the root zone of the crop.

In an empirical study carried out by Biazin et al., (2012) the success of micro catchment techniques depends on rainfall patterns and local soil characteristics and the practices would improve the soil water content of the rooting zone by up to 30%. *In situ* water harvesting techniques such as pot-holing, ridging, tied ridging, pit planting, and mulch ripping which are mostly used in banana farming help reduce runoff and hold water long enough to allow most of it infiltrate into the soil (Fandika et al. 2014).

### 2.2.3 Banana Plant Management

In a study carried out by Muthee et al., (2019) on banana production in Embu county and by Mbaka et al., (2008) in Kirinyaga and Meru county respectively established that common banana varieties in these areas include William hybrid, Grand Nain and Giant Cavendish. In Kirinyaga, Meru and Muranga, Kampala varieties are more preferred due to high yield results, long shelf life, and good taste (Mbaka et al., 2008 and Kabunga et al., 2012). The study further states that the choice of cultivar is mostly determined by its market demand, production suitability in the area, and the ease of managing the crop. Kasyoka et al., (2011) further attribute the choice of cultivar to local culture and exposure to new technologies through NGOs and extension services.

Muthee et al., (2019), (Vargas et al. 2009) found out that very few farmers practiced de-leafing which is considered as a hygienic practice in preventing the spread of diseases on the banana plant as well as moisture conservation On the other hand, other recommended practices such as pruning, mulching, spacing, pests, and disease management have been positively cited  to contribute to increasing in banana yields (Muthee et al., 2019; Kasyoka et al., 2011; Mbaka et al., 2008; Kabunga et al., 2012).

Technological innovation in banana farming has a close relationship with reproductive advancements such as the introduction of tissue culture bananas (Mohapatra, Mishra, Singh, &Jayas, 2011). Kabunga, Dubois, & Qaim, (2014) view the tissue culture technology to have come of age in Africa, but they contend they need for ex-post assessment, which they state is lacking across the continent. Kenya as well has limited ex-post assessments of the welfare effects of the technology; hence, more resources ought to be deployed to achieve the same. The authors use recent survey data and self-reflection accounting for technology adoption to analyze the impacts of tissue culture banana technology on various fronts such as household incomes and food security. They focus on Kenya as a representative of other countries involved in intensive banana farming in Kenya. To assess the extent of food security outcomes as a result of using tissue culture technology, they employ the Household Food Insecurity Access Scale (HFAIS). They are the first to use the tool since it was unveiled among research circles to assess impacts on various developments and policy changes on the society.

According to their estimates, based on treatment-effects models, they find that tissue culture banana adoption has the overall effect of increasing household and farm income by 50% and 153% respectively. Tissue culture technology also reduces food insecurity because it leads to increased yields per farm area. From these findings, it is evident that tissue culture technology is one of the agricultural innovations employable to increase banana production due to its welfare-enhancing effects.

The low production of bananas in Kenya is equally affected by a lack of access to high yield seeds (Wambugu& Kiome, 2001). Improved banana hybrids bred are increasingly being grown by farmers in West Africa due to their resistance to pathogens and pests, edible yield and stability, rapid cycling, and acceptable fruit processing attributes (Tenkouano et al. 2019)**.**In Kenya, the majority of the smallholder banana farmers banana stems come from locally sourced suckers mainly borrowed from neighboring farms that possess great risks of diseases (Wambugu & Kiome, 2001). These practices continue due to lack and high cost of clean material and lack of awareness on available biotechnology. Biotechnology innovation research and implementation, therefore, can begin from devising farmer networks and involving farming communities in the evaluation and selection process of a better way of selecting new banana seeds varieties suitable to their climatic condition and farming systems (Nasirumbi Sanya et al. 2017).

Muyanga (2009) study confirmed that some farmers combine both tissue culture banana biotechnology and non-tissue culture banana varieties in Kenya mainly because of production and productivity level. He further states that non-tissue banana varieties significantly exceed that of tissue culture bananas and the cost of production of tissue culture bananas exceeds that of non-tissue varieties. The results generally indicate that smallholder farmers in Kenya are yet to realize the full potential of tissue culture banana biotechnology.

### 2.2.4 Social-Economic Factors hindering Banana Productivity

Low banana productivity in many parts of Kenya is attributed to socio-economic and technical factors. Muthee et al., (2019) lists some of the socio-economic factors affecting banana farmers as; lack of proper marketing and processing channels for banana production, inadequate government support, and poor infrastructure, high cost of farm inputs and poor organization of farmer cooperatives. He further states that these constraints consequently increase the cost of production.

Access to extension and advisory services, to information, to farmer inputs, to credit and land are key social economic factors that can drive innovation in reference to the theory of diffusion of Innovation. The same factors can as well hinder adaptation of innovation (Ndiritu, Kassie, and Shiferaw 2014) and in return affect the overall productivity of the farm.



Key of the socio-economic dynamics that affect production level especially for banana farmers according to (Muthee et al. 2019) include inadequate information, inadequate modern extension services and lack of appropriate farm inputs. These factors are key as they are linked to the diffusion of innovation theory where information and knowledge dissemination by stakeholder such as extension and advisory agents can delay adaptation of innovation strategies. Land ownership is important as it is easier to invest in innovation strategies on owned farm compared to leased land.

#### 2.2.4.1 Extension and advisory services

Access to extension services is critical in promoting the adoption of modern agricultural production technologies because it can counterbalance the negative effect of lack of years of formal education in the overall decision to adopt technologies(Van Brussel, Boelens, and Lauwers 2016). Kahan &

D.G.,(2007) defines extension services as the intermediate services between farmers and researchers. According to Kahan, agricultural extension officers deliver research information to farmers and help them implement best practices on the farm. They operate as communicators and facilitators who help farmers to make the best decisions through appropriate knowledge implementation to obtain the most optimal results.

According to Babu et.al., (2015), Agricultural extension systems in developing countries continue to face numerous constraints that undermine the delivery of quality services and information to smallholders highlighting challenges such as wide dispersion of poor farmers, varied information needs of farmers, and inadequate financial support for extension agencies.

Moreover, Kahan & D.G., (2007) observe the role played by NGOs and other private players in providing extension services. He states that the capacity and skills of private extension services providers are weak because staffs are generally young and they lack practical experience and specialized expertise to provide credible management advice.

Banana farming also requires farm management to be effective thereby requiring investment inadequate training. According to (Van Brussel et al. 2016) the actual adoption of the improved practices and technologies that are promoted through the provision of extension services is conditioned by several households and farm levels such as human capital, physical capital, and social capital.

#### 2.2.4.2 Access to Information

Social learning is widely practiced by most farmers to cope with this unequal distribution though its practices have hardly been documented in passing on the knowledge of agriculture and rural development or embedding it into the local system of knowledge production (Leta et al. 2018).

Farmers, therefore, are likely to acquire knowledge through social networks through communication, observation, collective labor groups, public meetings, socio-cultural events, and group socialization (Leta et al. 2018). The extension knowledge and new technologies (such as the use of improved seeds) are, for example, rather distributed in areas closer to agricultural research stations (Kabunga et al. 2012).

#### 2.2.4.3 Land Ownership and Land size.

A report by the World Bank report (2012) links to access to land with the adoption of agricultural technologies. Historically, according to the World Bank report, African cultures have patriarchal land ownership traditions that exclude women from having full rights over land. Women, therefore, have access to land through their husbands. Divorced women lose land that formerly belonged to their ex-husbands. For married women, they use the land but the exclusive rights of ownership remain to the husband. Thus, if a banana farmer intends to implement an innovation that requires securing land tenure may disadvantage women with the entrepreneurial spirit to be involved in banana agribusiness. The same World Bank report further observes that it is not uncommon to find that technological interventions aimed at improving productivity on land worked by women may have them replaced by men.

Muyanga, (2009), the empirical study further cites that ownership of land with title deed increases the probability of adopting innovation strategies as it is secure to invest in the land. On the contrary, other scholars such as (Mwangi and Kariuki 2015)do not attribute land ownership rights as the main determinant to adopt innovation.

#### 2.2.4.4 Access to Credit

Access to financial services to farmers is widely perceived as an effective strategy for promoting the adoption of improved technologies(Franklin and Manfred 2006). Wasala, (2014) observes that access to credit has a positive correlation with adopting new technologies such as macro-propagation and micro-propagation strategies such as tissue culture technology use. The research further states that expanding the financial ability of small-scale farmers to be able to purchase the inputs they require to compliment technology they need to maximize banana yields citing a 4.8% increase in technology adoption for every unit credit facility a smallholder farmer obtains (Wasala 2014). The increase arises from the fact that credit enables the farmers to acquire the funds they need to invest in new technology. On the flip side, the same research indicates that the rate of technology adoption tends to decrease as farmers are exposed to quality extension services. It further states that farmers who have access to credit tend to increase productivity as they can easily access farm inputs

Specifically, technology adoption reduces with a significant percentage for every extra visit by extension officers (Marley 2015). The reason for this trend is that extension services focus more on the production of traditional crops such as maize than on horticultural crops such as bananas. The former requires less technology adoption; hence, the officers are unlikely to encourage or advise farmers to choose the right innovative technologies to use on their farms.

Cooperatives are instrumental in mobilizing farmers and are a huge source of information that can be used to improve farmers' livelihood (Babu et al. 2015). However, cooperatives need additional support to adopt the successful model for ensuring the livelihoods of the members.

#### 2.2.4.5 Access to farm input

According to Marley, (2015) there is a link between access to farm inputs and the possibility of innovative banana farming. Marley contends that institutional factors such as the existing policy environment affect the availability of farm inputs for banana farmers. The long-term effect is that farmers without access to farm inputs have reduced profitability from technologies applied in banana farms. For example, farmers using tissue culture technology may find that they need further information on the extent to which the technology works with certain farm inputs (Nyombi 2013). Hence, Marley also connects the need for information access by farmers as a means to enable them to make the right decisions about the special farms' inputs to use; hence, they are likely to pursue innovative practices in the context of existing best practices. Other than information, Marley also finds that poverty affects access to farm inputs thereby altering innovation by banana farmers. Inadequate access to markets is also one of the factors related to the lack of access to adequate and relevant farm inputs.

**Table 2.1 Summary of the Knowledge Gaps**

| Author (year) | Objective of the study | Knowledge gaps identified |
|---|---|---|
| Vanlauwe et al., (2015) | Influence of Integrated soil fertility management in Sub Saharan Africa. | The study's context was unravelling local adaption of Integrated Soil Management in Sahara Africa. It revealed the connection between fertilizer applications within farm soil fertility gradients has the potential to increase agronomic efficiency however a better understanding of the influence of biophysical and socioeconomic factors on the performance of technologies at different scale need to be studied further. |
| (Kasyoka et al. 2011) | To determine distribution of bananas varieties, and the availability and sources of planting materials in Central and Eastern provinces of Kenya | The research focused on use of naturally regenerated suckers as planting materials and how they continuously perpetuated the spread of banana diseases and pests that substantially reduce yields. Whereas the current study will also focus on that declining soil fertility and moisture stress as important production constraints giving a more integrated approach on innovative strategies around soil, water and the banana plant management . |
| (Biazin et al. 2012) | To establish the significant potential for improving rainwater-use efficiency and sustaining rain fed agriculture | The study focused on potential ways of blending rainwater harvesting ideals with agronomic principles. This study will put more emphasis on improving the indigenous practices i.e. how soil management practices can be used to ensure water –use efficiency i.e. through mulching and intercropping. |
| (Ndiritu et al. 2014) | To identify systematic gender difference in the adaptation of sustainable agricultural intensification in Kenya | The study focused on comparison of male and female plot mangers, female like hood to adopt agricultural intensification practices and the stuffy finds out no gender differences in the adoption of soil and water conservation measures, improved seed varieties, chemical fertilizers, maize-legume intercropping, and maize-legume rotations does not apply. This study will look at accessibility to information, inputs, extension services, land and credits and whether it influences the choice of innovative strategies adopt. |

## 2.5: Conceptual Framework

**Figure 2.1 Conceptual Framework**

**Independent Variables- Innovative Strategies** **Dependent Variables**

**Soil Management**

- Integrated soil management
- Intercropping, Mulching/ tillage
- Soil testing

**Water Management**

- Irrigation techniques
- Water Harvesting

**Banana Plant Management**

- Source of tubers
- Use of tissue culture bananas

**Socio Economic Factors**

- Access to Credits
- Access to Land and land ownership
- Access to information
- Access to Extension service
- Access to farm input

**Productivity**

- Weight of each banana comb in Kgs
- Yield per acre
- Income per acre

**Source: Author (2020)**

## 2.6. Operationalization of Variables

### Table 2.2 Operationalization of Variables

| Variable | Definition | Indicator | Category of Data | Measure |
|---|---|---|---|---|
| Soil Management | Soil management is the practice of treating and protecting soil to retain its nutrients and improve its function (FAO 2018) | Fertilizer use | Binary | Use of either organic or no organic fertilizer |
| | | Intercropping and Mulching | | Number of crops planted |
| | | Soil testing | | Last soil testing done. |
| Water Management | The control and movement of water through distributing and harvesting (Loucks 2015) | Irrigations techniques | Binary | Type of irrigation used |
| | | Water harvesting techniques | | Type of water harvesting being practices |
| Banana plant management | Agricultural practices use to improve the growth, development, and yield of the banana crop (Brian Ssebunya 2011) | | Binary | |
| | | Spacing | | Distance between each banana plantation |
| | | Tissue culture banana | | Use of tissue culture bananas |
| Social-economic Factors | Society and economic-related factors that affect the adoption of innovation strategies (Ndiritu et al. 2014) | Education level | Continuous | Year of education |
| | | Access to credit | Binary | The number of credit facility services option.<br><br>Credit facility obtained in the last one year |
| | | Access to training | | Member of farmer group/ cooperative<br><br>Any form of training in banana farming |
| | | Access to extension services | | Distance to nearest Extension service provider |
| | | Income level | Discrete | Net income, number of livestock owned |
| | | Access to land | Binary | Rented or owned. Has title deed or not |

| | | | | |
|---|---|---|---|---|
| | | Access to Information | Binary | Member of farmer group/ cooperative<br><br>Distance to market.<br><br>Distance to nearest seed dealer/ pesticide dealer<br><br>Distance to nearest cooperative/ farmers group |
| Productivity | The ratio of faming outputs to farming inputs (FAO 2017) | | Continuous | |
| | | Income per acre | | Total number of banana plant in a farm and total income |
| | | Yield per year | | Total Kgs of banana harvested in a year |
| | | Weigh of each banana comb | | Weight in Kgs |

**Source: Author (2020)**

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.0 Introduction

This chapter outlines the research methods and procedures that were used in conducting the study. It encompasses the following sections: research design, study area, target population, sampling techniques and research methods, and validity of the instruments, reliability of the instruments, data collection, and data techniques.

## 3.1 Research Design

A research design provides a plan and structure of the research in obtaining answers to the research questions under investigation (Kothari, 2004). The study adopted descriptive research design which was used to explain the relationship between the dependent and the independent variables. According to Mugenda and Mugenda (2003), descriptive research is a process of collecting data to answer questions concerning the status of the subjects in the study.

## 3.2. Target Population

The target population of this study was 147,000 smallholder banana farmers in Kirinyaga County targeting three constituencies Kirinyaga Central, Ndia, and Gichugu. The target population records were as per the 2020 concept note on 'Revitalization of the Coffee Industry in Kenya' by The Ministry of Agriculture Crop Development and Agricultural Research Department (Govt 2020) which categorized smallholder farmers from Central Region. The three constituencies have a population of 372, 959 as per the Kenya National Bureau of Statistics (KNBS 2019).



The population is a well-defined or specified set of people, group of things or events which are being investigated. Cooper & Schindler, (2006) defined population as the total collection of elements to which a researcher wishes to make inferences. Thus the populations should fit a certain specification which the researcher is studying.

The three constituencies selected for the study provided an adequate sample for generalization because they have the highest number of smallholder farmers growing bananas in Kirinyaga county.

## 3.3: Sampling Design

According to Mugenda & Mugenda (2003) a sample is the part of the population research interest that is selected for analysis. In other words, it is the process of obtaining information about an entire population by examining only a part of it (Kothari, 2014). In this study, simple random sampling was used. Samples were taken from each stratum or subgroup of the population, for example, Kirinyaga Central, Ndia, and Gichugu.

The sample was categorized into three strata representing the three constituencies. Acceptable sample size has a confidence level of more than 95% and less than 10% error (Bryan, 2016). A sampling error of 6% will be used in the study for obtaining the minimum sample size and increasing the accuracy for an appropriate sample size.

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

Where N = population size

e = sampling error at 0.05

n = sample size

Therefore $$n = \frac{147{,}000}{1+147{,}000\,(0.05)^2}$$

This means that in order to achieve 5% sampling error at 95% confidence level, the lowest acceptable number of respondents is approximately 400. Proportionate random sampling was used to allocate the samples to each constituency as shown in Table 3.1 below

**Table 3.1 Sample size**

| Constituency | Total population of the area | Population of smallholder farmers | Sample size |
|---|---|---|---|
| Kirinyaga Central | 122, 740 | 40,913 | 143 |
| Ndia | 114, 660 | 38, 220 | 95 |
| Gichugu | 135, 559 | 67, 778 | 162 |
| **Total** | **372, 959** | **146, 911** | **400** |

### 3.4. Data Collection Methods/ Instruments

The instrument used in the study was a questionnaire. A cover letter (Appendix I) and a participant consent note (Appendix II) were attached to the questionnaire to introduce the researcher and provide respondents with information on the study. The questionnaire (Appendix III) contained both open –ended and closed ended questions that had been constructed to address the four research objectives. A numerator was used to help collect data by helping translate the questionnaire to a language the farmers understood.

### 3.5. Data Analysis and Presentation

Data analysis refers to the process of obtaining raw data and using procedures for interpreting and converting it into useful information that can be used by the end-users in approving or disapproving theories, drawing conclusions, and thereby supporting decision making(Kothari, 2009). The collected information from the questionnaires was analyzed using the Statistical Program for Social Sciences (SPSS). The data collected were coded and categorized to make it easy to analyze and make conclusions and meaning of the data. Checking of errors before data analysis was undertaken for the correctness of data input to the system.

#### 3.5.1 Descriptive Statistics

This was used to analyze the general productivity of the farm. The mean and standard deviation were examined in this case. Information related to the farmers' characteristics and some of the social-economic factors were summarized in terms of frequencies and percentages.



#### 3.5.2 Correlation analysis

Correlation analysis was conducted on all four objectives. This was done to determine whether there was an association between the dependent and independent variables and the strength it presents (Cooper & Schindler, 2006). The correlation coefficient value determines the measure of linear association between two variables where the coefficient is always between -1 and +1. A coefficient of -1 means that variables are perfectly associated in a negative line r sense,) means that

there is no association between variables and +1 indicates that the variables are perfectly associated in a positive liner sense (Cooper and Schindler 2006).

### 3.5.3 Multiple Regression analysis

This analysis is used when there is more than one independent variable. After conducting a correlation analysis all the specific objectives of the study and finding an association between variables, the next step was to carry out a multiple regression analysis. The model applied to the study is suitable for the assessment of the relationship between variables in social sciences. The specific model applied is highlighted below:

$$Y = \beta 0 + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \beta 4x5 + \beta 6x\ 6 + \in=$$

Where: Y is the dependent variable – Productivity

β0 is the constant

β1, β2, β3, and β4 are the regression coefficients for the variables, yield per acre, the weight of the banana comb per plant and income per acre respectively.
X is the independent variable

x1, x2, x3, x4, are soil management, water management, banana plant management, and social-economic factors

ε is the error term

### 3.6 Research Quality

The questionnaire was tested for validly and reliability to ensure quality. The questionnaire was pilot tested to check for it face validity (Cooper and Schindler, 2003). A face validity test was undertaken by administering the initial questionnaires on fifteen randomly selected respondents. The feedback from the fifteen respondents was used to improve on the questionnaire structure, simplify difficult questions and remove ambiguous questions. Resulting from these changes, the final questionnaire was considered valid.

The Cronbach alpha which was the coefficient of the internal constituency was used to quantify the reliability of the questionnaire. Integral consistency quantifies the associations that exist between the various items on the same test whether various items that suggested to measure the same general construct result to similar scores. Castilian (2009) presents the decision rules as follows: >0.9 - Excellent, > 0.8- Good, >0.7>- Acceptable, > 0.6- Questionable, >0.5- Unacceptable. The reliability test results showed that all the variables were reliable as shown by the associated Cronbach alphas that were greater than 0.7. The pretest analysis of the questionnaire used in the pilot stage produced alpha+ 0.545. After improvement on its face validity the questions in the questionnaire resulted in alpha = 0.78 which the questionnaire was reliable.

**3.7 Ethical considerations**

The study was undertaken within the ethical frameworks of social research. In particular, the researcher was guided by the legal and moral principles of social research as outline by Bryan (2001) which are; there should be informed consent, there should be no deception involved, there is no harm to participants, and there is no an invasion of privacy. The researcher acted openly and truthfully to promote accuracy guided by the ethical principles of integrity and objectivity. From the onset, an introductory letter requesting access and outlining in brief the purpose of the research was presented to respondents.

The confidentiality of the information supplied by research objects and the anonymity of respondents was respected. Research participants were allowed to participate voluntarily, and free from coercion. The researcher pursed approval for the study from Strathmore University's ethics board (Appendix IV) and the National Commission for Science, Technology and Innovation (Appendix V).

## CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION

### 4.1. Introduction

This chapter comprises data analysis, findings, and interpretation. The results are presented in tables and diagrams. The analyzed data was arranged under themes that reflected the research objectives. The demographic information of the farmers, descriptive statistics of the findings and correlation and regression analysis as well as a summary of the chapter is provided.

### 4.2 Response Rate

The number of questionnaires administered was 400. A total of 302 questionnaires were properly filled and returned. This represented an overall successful response rate of 75.5% as shown in Table 4.1. This response rate was considered adequate based on the assertions of recognized scholars, Mugenda & Mugenda (2003). 5.25% of the questionnaires were not filled properly hence not used for analysis and 19.25% did not respond to the questionnaire.

**Table 4.1 Response Rate**

| Response | Frequency | Percentage |
|---|---|---|
| Responded | 302 | 75.5% |
| Responded and not fully filled | 21 | 5.25% |
| Did not respond | 77 | 19.25% |
| **Total** | **400** | **100** |

The respondents were from three Constituencies in Kirinyaga as summarized below.

**Table 4.2 Total number of respondents per Constituency**

| Constituency | Total Number of respondents | Expected number of respondents |
|---|---|---|
| Gichugu | 117 | 162 |
| Ndia | 83 | 95 |
| Kirinyaga Central | 102 | 143 |
| **Total** | **302** | **400** |

Most farmers were elderly past 60 years getting to them was also difficult, they were also not willing to share too much information such as income, hence some questionnaires were not fully filled.

### 4.3 Demographic and Farm Statistics

This section consists of information that describes basic characteristics of the farmer's such as gender, age, year of study employment status, and sources of income.

#### 4.3.1. Gender of the farmers

The results indicated the majority of farmers as 47% were female while 53% were male. This shows that we have more male farmers than female farmers in the three constituencies. We can denote more males are practicing farming compared to females.

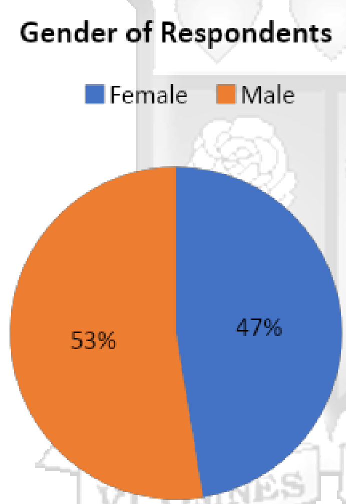



**Figure 4.2 Gender of Respondents**

#### 4.3.2. The age bracket of the farmers

The study findings indicated that the average age of the farmers is 53.57 years. 16.9% of farmers were aged below 40 years, the youngest being 24 years. This implies that the majority of the farmers are highly experienced in farming and very few young people are interested in farming.

#### 4.3.3. Year of study of the farmers

The study findings further indicate that 6% of the farmers have no education at all, 22% have attained primary education, 59% have secondary education, 10% have attained college education and 3% have University level education. The findings are shown in Figure 4.1. From this we can conclude that at least half of the respondent have attained secondary education, giving them the basics on framing techniques and are able to easily practice innovative strategies in their farms as well as see more knowledge through other channels.

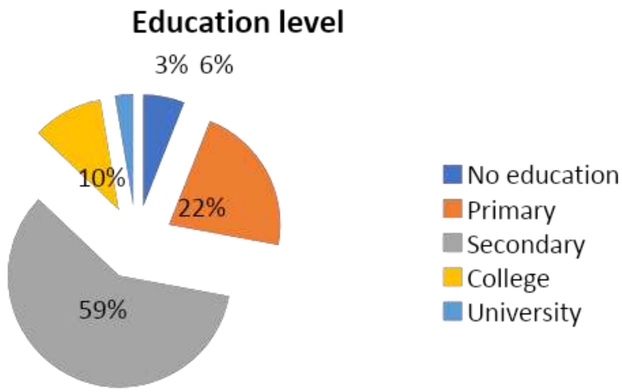



**Figure 4.3 Education level**

### 4.3.4: Source of Income

The study wanted to establish other sources of income for the banana farmers. According to the findings, 45% said get it from coffee farming, 74% from horticultural crops i.e. French beans, tomatoes, and vegetables, 25% from either livestock or tea 1% said they get it from rice production. Coffee has the second highest percentage as it is the main cash crop in Gichugu and Ndia. Most farmers in that area practice intercropping of Coffee and Bananas and other horticultural crops that are considered as high value such as French bean and tomatoes.

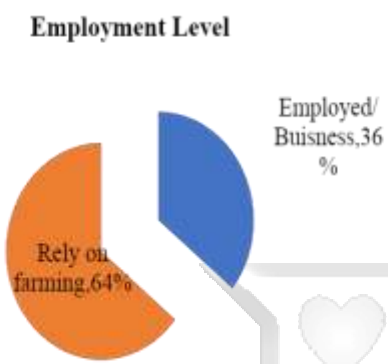
**Table 4.3 Source of Income**

| Other crops | Frequency | Percentage |
|---|---|---|
| Coffee | 137 | 45 |
| Rice | 2 | 1 |
| Horticultural Crops | 223 | 74 |
| Others ( Livestock and tea) | 197 | 25 |

### 4.3.5: Employment level

According to the findings, a total of 39.4% of the farmers are employed and/or run other businesses outside farming and 70.6% rely purely on farming. This shows that the biggest percentages of the smallholder farmers in the three constituency rely on farming as the main source of income and also as a source of employment.

**Figure 4.4 Employment Level**




### 4.3.6: Land Ownership

The researcher wanted to investigate the ownership of the small scale banana farmers. According to the findings displayed in the figure below, 94% of the respondents owned the farms and had title deeds; others, as shown by 6%, said that the farms were leased respectively. Based on the findings, access to land is not a factor that hinder adaptation of innovation strategies in Ndia, Gichugu and Kirinyaga Central as majority have their own land.

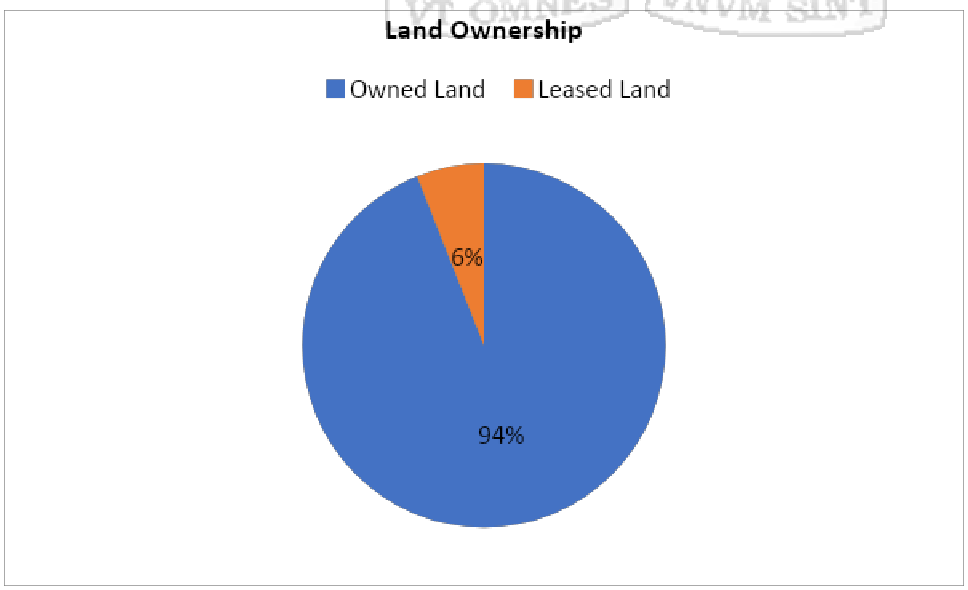



**Figure 4.4 Landownership**

### 4.3.7 Farm Statistics

#### 4.3.7.1 Size of Farm

**Table 4.4 Size of acreage of Farm**

| Acres | Frequency | Percentage |
|---|---|---|
| Below 1 Acre | 47 | 15 |
| 1 - 2.5 Acres | 213 | 70 |
| 3- 4.5 Acres | 35 | 12 |
| 5- 6.5 Acres | 5 | 2 |
| Above 7 Acres | 2 | 1 |
| **Total** | **302** | **100** |

The study established that 70% of the respondents had a farm size of 1 to 2.5 acres 15% had below one acre, 12% said 3 - 4.5 acres, 2% said between 5 to 6.5 acres whereas a few as shown by 1% said above 7 acres. A big percentage of the farmers are those with 1 to 2.5 acres of land. This can be an indication that most of them practice mixed farming for survival based on the land size.

#### 4.3.7.2 Acres under Banana Cultivation

**Table 4.5 Acres under Banana Cultivation**

| Acres | Frequency | Percentage |
|---|---|---|
| 0.1 to 0.3 | 210 | 69 |
| 0.4 to 0.75 | 56 | 18 |
| 1 to 3 | 35 | 12 |
| Above 4 | 1 | 1 |
| **Total** | **302** | **100** |

The study requested to know acres of land under banana cultivation. According to the study, 69% of the respondents said that the area under banana cultivation in the farms is between 0.1 to 0.3acres, 18% between 0.4 to 0.75 acres 12% between 1 to 3 acres, and 1% above 4 acres respectively. This was a clear indication that very small pieces of land are dedicated to banana farming in most of the farms in Kirinyaga County. Most of them dedicate the farms to coffee, tea, and horticultural crops which fetch good prices compared to bananas.

### 4.3.7.3 Level of banana Farm productivity in the last 24months

**Table 4.6 Productivity of the banana farms in the last 24 months**

| Productivity levels | Frequency | Percentage |
|---|---|---|
| Declined Significantly | 0 | 0 |
| Declined somewhat | 9 | 3 |
| Remained the same | 153 | 51 |
| Improved somewhat | 140 | 46 |
| **Total** | **302** | **100** |

The researcher sought out to establish the respondents' level of farm productivity in the last 24 months. According to the findings, 0% of the respondents indicated their farms have not declined to a bigger extent, 3% stated that their farms' productivity level has declined somewhat, 51% indicated productivity levels in their farms remained the same, 47% stated that their farms' productivity improved somewhat and none had witnessed a significant improvement in their farms' productivity. Based on the findings the researcher concluded that the majority of the farmers are not very keen or are unaware of strategies to use to improve their lands for purposes of increasing productivity.

### 4.3.7.4 Farm Information and Productivity

**Table 4.7 Farm Information and Productivity**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | **N** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** |
| Land size | 302 | 0.10 | 6.00 | 0.45 | 0.59 |
| Number of banana plants | 302 | 20.00 | 2400.00 | 107.54 | 207.99 |
| Banana Harvested last year ( Kgs) | 302 | 400.00 | 108,000.00 | 3,852.28 | 9,934.55 |
| Average Kilograms of each banana comb. | 116 | 17.50 | 45.00 | 26.79 | 5.64 |
| The selling price of banana per Kg? | 302 | 7.50 | 17.50 | 13.51 | 2.84 |

| | | | | | |
|---|---|---|---|---|---|
| Income from banana farm | 302 | 1000.00 | 2,000,000.00 | 64,075.17 | 180,077.73 |
| Household income | 302 | 10,000.00 | 10,000,000.00 | 292,549.67 | 645,924.45 |
| Income from other farm activities | 302 | 1500.00 | 300,000.00 | 10,723.51 | 21,541.67 |
| Valid N (list wise) | 116 | | | | |

From the table above, the mean size of the banana plantation from 302 respondents was 0.45 acres with an average deviation of 0.59. The maximum and minimum size of the plantation was 6 acres and 0.1 acres respectively. The mean size of the number of banana plantations from 302 respondents was 107.54 plants with an average deviation of 207.99. The maximum and the minimum number of banana plants was 2,400 and 20 plants respectively. The 302 respondents were asked how much banana they harvested within the last one year; the mean was 3,852.28 with a standard deviation of 9,934.55. The maximum harvest being 108,000Kgs and a minimum of 400Kgs. The average Kilograms of each Banana comb had a mean of 26.79Kg and a standard deviation of 5.64Kg with a maximum of 45kgs and a minimum of 17.50Kg. The minimum selling price of banana per kg was Kshs7.50 and a maximum of Kshs45 with a mean of Khs26.79 and a standard deviation of Kshs2.84 of the total 302 respondents. The average income per year from the banana farms ranges from a minimum of Kshs1000 to Kshs2,000,000 as maximum with a mean of Kshs64,075.1 and a standard deviation of Kshs180, 077.73. Average household income in a year ranges from a maximum of Kshs10, 000,000 to a minimum of Kshs10,000 with a mean of Kshs 292, 549.67 and a standard deviation of Kshs645, 924.5 from the 302 respondents. Income from other farm activities in a month had a mean of 10,723.51 and a standard deviation of 21,541.67. The maximum and the minimum income from other farm activities every month was Kshs300,000 and Kshs150,000 respectively.

### 4. 3.7.5 Relationship between the size of banana plantation, number of banana plants and average kg per banana comb

Spearman’s rho correlation was conducted on the relationship between the size of banana plantation, the number of banana plants, and average kg per banana comb and the strength of these relationships. The results are as shown below;

**Table 4.8 Correlations Results for Farm Productivity**

| Correlations | | | | |
|---|---|---|---|---|
| | | Land size of banana plantation | Number of banana plants | Average Kilograms of each banana comb |
| Land size of banana plantation | Pearson Correlation | 1 | .959** | .445** |
| | Sig. (2-tailed) | | 0.000 | 0.000 |
| | N | 302 | 302 | 116 |
| Number of banana plants | Pearson Correlation | .959** | 1 | .526** |
| | Sig. (2-tailed) | 0.000 | | 0.000 |
| | N | 302 | 302 | 116 |
| Average Kilograms of each banana comb | Pearson Correlation | .445** | .526** | 1 |
| | Sig. (2-tailed) | 0.000 | 0.000 | |
| | N | 116 | 116 | 116 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

Spearman's correlation coefficient (rs) should always fall between +1 and -1 (Cooper & Schindler, 2014). A coefficient of -1 means that the variables are perfectly negatively related, 0 will mean that there exists no relationship between the variables and +1 will mean that the variables are perfectly positively correlated (Cooper & Schindler, 2014). These values could also be interpreted as follows; 0.00-0.19 very weak, 0.20-0.39 weak, 0.40-0.59 moderate, 0.60-0.79 strong, and 0.80-1.00 very strong.

From the table, there was a positive correlation between the three variables and it was statistically significant at 5% level of significance. The size of the banana plantation and the number of banana plants had a correlation coefficient of ($R=0.959$, $p< 0.05$). This means that an increase in the size of the banana plantation will lead to an increase in the number of banana plants and there is a very strong correlation.

There was a positive correlation between the size of banana plantation and average kg per banana comb. The relationship was statistically significant *($R=0.445$, $p <0.05$).* This means that an increase in the size of the banana plantation will lead to an increase in the average kg per banana comb and the relationship is moderate.

## 4.4 Soil management strategies and banana productivity

### 4.4.1 Descriptive statistics Soil Management Strategies

#### 4.4.1.1: Soil testing

The Figure 4.5.1 shows the last soil testing done by the respondents. Majority at 83% have never done soil testing on their farms, 14% did soil testing 7 to 10 years ago, 2% did soil testing 4 to 6 years ago and 1% between 1 and 3 years. This shows a big gap in the importance of soil testing among the farmers in all the three constituencies the research was conducted.

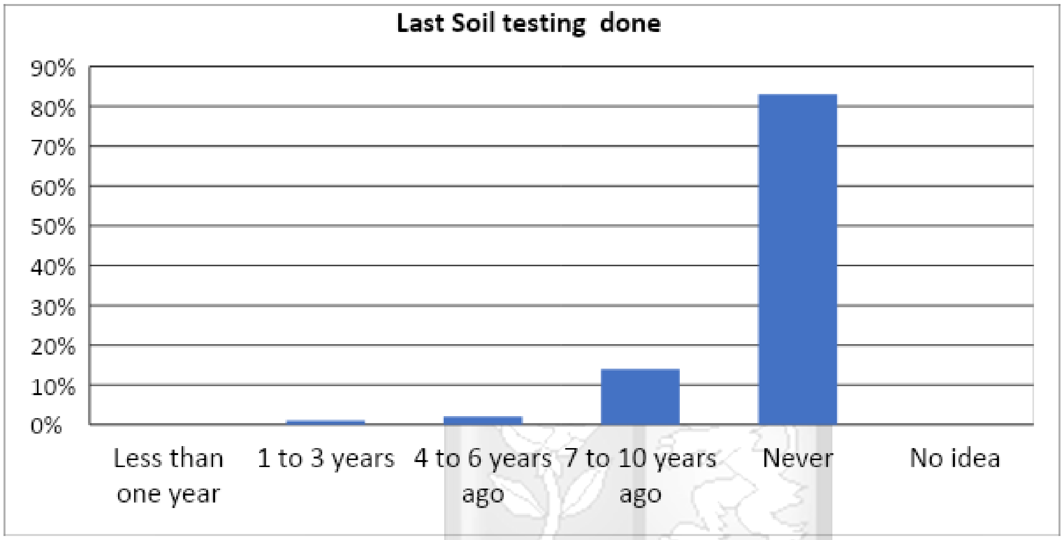



**Figure 4.6 Last Soil Testing**

#### 4.4.1.2: Soil Management Strategies

The table low shows the soil management used by the farmers. The majority practice Agroforestry and Minimum tillage followed by Mulching at 85%, 80%, and 77% respectively. In Gichugu and Ndia intercropping is common as bananas are intercropped with coffee and tea unlike in Kirinyaga Central where farmers concentrate on banana farming only. Agroforestry is high in Gichugu as it is also close to the Mt. Kenya forest, unlike Kirinyaga Central and Ndia.

**Table 4.9 Soil Management Strategies Used**

| Constituency | Minimum Tillage | Intercropping | Mulching | Agroforestry |
|---|---|---|---|---|
| Gichugu | 119 | 121 | 93 | 111 |
| Ndia | 40 | 71 | 56 | 73 |
| Kirinyaga Central | 84 | 11 | 84 | 73 |
| **Percentage** | **80%** | **67%** | **77%** | **85%** |

### 4.4.1.3: Fertilizer and Pesticide Use

The table 4.4.2 below shows the number of respondents who use fertilizer in their farms is at 98%, those who use animal manure/ compost manure are 99% and those who use pesticides on their farm at 23%.

**Table 4.10 Use of Fertilizers and Manure**

| Soil Management Practices | Frequency | Percentage |
|---|---|---|
| Fertilizer Use | 298 | 98 |
| Use of organic manure | 299 | 99 |
| Use of pesticides | 72 | 24 |

## 4.4.2 Correlation Analysis for Soil Management Strategies

To investigate the relationship between the Soil management strategies and banana productivity, a correlation analysis of the various components identified as measuring the variables effectively was carried out using the Pearson product moment correlation coefficient (r). It is observed in Table 4.5.2 below that there is a weak positive correlation *($R=0.130$, $p < 0.05$)* testing done 1 to 3 years on banana productivity. This means that increasing soil testing would lead to increase in banana productivity. The value of correlation coefficient is statistically significant at 5% level of significance. There was a weak positive correlation between use of fertilizer and banana productivity and the relationship was significant *($R=0.278$, $p < 0.01$).* This means that an increase in the use of fertilizer will lead to increase in banana productivity. Use of pesticides had a negative effect on banana productivity and the effect was significant *($R= -0.621$, $p < 0.01$).* An increase in use of pesticides will have a corresponding reduction in banana productivity.

**Table 4.11 Soil Management Strategies Correlation Matrix**

| Correlations | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Banana Productivity | Soil testing done 1 to 3 years ago | Soil testing done 4 to 6 years Ago | Soil testing done 7 to 10 years Ago | Use of fertilizer | Use of organic manure | Use of pesticides |
| Banana Productivity | R | 1 | .130* | .129* | .113* | .278** | -0.097 | -.621** |
| | p value | | 0.024 | 0.025 | 0.049 | 0.000 | 0.092 | 0.000 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Soil testing done 1 to 3 years ago | R | .130* | 1 | -0.015 | -0.040 | .198** | -0.014 | -0.101 |
| | p value | 0.024 | | 0.790 | 0.487 | 0.001 | 0.805 | 0.081 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Soil testing done 4 to 6 years Ago | R | .129* | -0.015 | 1 | -0.062 | 0.027 | -0.022 | -0.017 |
| | p value | 0.025 | 0.790 | | 0.284 | 0.645 | 0.704 | 0.767 |
| | N | 302 | 303 | 303 | 303 | 302 | 301 | 302 |
| Soil testing done 7 to 10 years Ago | R | .113* | -0.040 | -0.062 | 1 | -0.060 | -0.057 | -0.005 |
| | p value | 0.049 | 0.487 | 0.284 | | 0.298 | 0.327 | 0.930 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Use of fertilizer | R | .278** | .198** | 0.027 | -0.060 | 1 | -0.045 | -.250** |
| | p value | 0.000 | 0.001 | 0.645 | 0.298 | | 0.439 | 0.000 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Use of organic manure | R | -0.097 | -0.014 | -0.022 | -0.057 | -0.045 | 1 | 0.080 |
| | p value | 0.092 | 0.805 | 0.704 | 0.327 | 0.439 | | 0.166 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Use of pesticides | R | -.621** | -0.101 | -0.017 | -0.005 | -.250** | 0.080 | 1 |
| | p value | 0.000 | 0.081 | 0.767 | 0.930 | 0.000 | 0.166 | |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | |

### 4.4.3 Soil Management Strategies Regression Analysis

The objective was to investigate the effects of soil management strategies on banana productivity. enhancing banana productivity among smallholder banana farmers in Kirinyaga County, Kenya. Multiple linear regression was performed.

**Table 4.12 Model Summary for Soil Management Strategies**

| Model Summary[b] | | | | | |
|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
| 1 | .660[a] | 0.435 | 0.424 | 0.78464 | 1.842 |
| a. Predictors: (Constant), a Use of pesticides, 7 to 10 years Ago, 4 to 6 years Ago, Use of animal manure/ compost manure, 1 to 3years Ago, Use fertilizer in your farm | | | | | |
| b. Dependent Variable: Banana productivity | | | | | |

The R which is the coefficient of correlation, 66% shows there is a strong relationship between the dependent and independent variables. Since this is a positive relationship it suggests that an increase in the independent variables will lead to an increase in the banana productivity which was measured using yield per acre. The coefficient of determination R square tells us what percentage of the independent variables can be used to predict the dependent variable. It is generally a measure of the goodness of fit of the regression model. Thus, based on the above table it shows that 43.5% of the individual independent variables can be used to predict the yield per acre hence they are good predictors of the model. The adjusted R square shows the proportion of variation of the dependent variable as explained by the independent variables when the number of independent variables is taken into consideration. From the results obtained, the adjusted R square is 42.4% which means that the proportion of the dependent variable explained by the independent variables combined in the regression equation is 42.4%.

The overall significance of the model was assessed using ANOVA table as shown in Table 4.5.3.2 below.

**Table 4.13 ANOVA Results for Soil Management Strategies**

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 139.606 | 6 | 23.268 | 37.793 | .000[b] |
| | Residual | 181.003 | 294 | 0.616 | | |
| | Total | 320.609 | 300 | | | |
| a. Dependent Variable: ln_ypc | | | | | | |

From the table the model is statistically significant *at 5% level of significance, (F = 8.005, p < 0.05).* Based on the regression results, soil management strategies were statistically significant affecting banana productivity as shown in Table 4.5.3.4

**Table 4.14 Coefficients of Independent Variables Soil Management Strategies**

| Coefficients[a] | | | | | |
|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | t | Sig. |
| 1 | (Constant) | 9.546 | 0.443 | 21.563 | 0.000 |
| | Soil testing done 1 to 3 years ago | 0.542 | 0.466 | 1.162 | 0.246 |
| | Soil testing done 4 to 6 years Ago | 0.844 | 0.301 | 2.804 | 0.005 |
| | Soil testing done 7 to 10 years Ago | 0.377 | 0.133 | 2.845 | 0.005 |
| | Use of fertilizer | 0.469 | 0.167 | 2.808 | 0.005 |
| | Use of organic manure | -0.258 | 0.325 | -0.793 | 0.428 |
| | Use of pesticides | -1.394 | 0.110 | -12.649 | 0.000 |
| a. Dependent Variable: Banana productivity | | | | | |

Based on the regression results, soil management strategies statistically significant affecting banana productivity. Soil testing done 4 to 6 years ago had a positive significant effect (*t =2.804, p value < 0.05)* on banana productivity. A unit increase in soil testing 4 to 6 years ago would lead 84.4% increase in banana productivity holding other factors constant. Soil testing done 1 to 3years did not show positive significance as expected. The implication can the number of people who did soil testing within that period were below 1%, making is hard to compare the results with those who did soil testing between 4 to 6 years. Use of fertilizer had a positive and significant influence on banana productivity as given by ($\beta$ = 0.469, $t$ = 2.808, $p<0.05$). The implication of these findings was that a unit increase in use of fertilizer would lead to increased banana productivity by 46.9%. Use of pesticides had a negative and significant influence on banana productivity as given by ($\beta$ = -1.394, $t$ = 12.649, $p<0.01$). The implication of these findings was that a unit increase in use of pesticides would lead to decreased banana productivity by 39% holding other factors constant.

## 4.5: Water management strategies on banana productivity

### 4.5.1 Descriptive statistics of water management strategies

#### 4.5.1.1: Irrigation Method

The table below shows the irrigation methods practiced by the farmers. 126 out of 302 respondents do not use any form of irrigation, they are dependent on rainwater, 103 of the respondents use the Furrow method, 2 respondents stated they use hose pipes, 23 pump water from the river and 48 of the 302 respondents use Sprinkle methods.

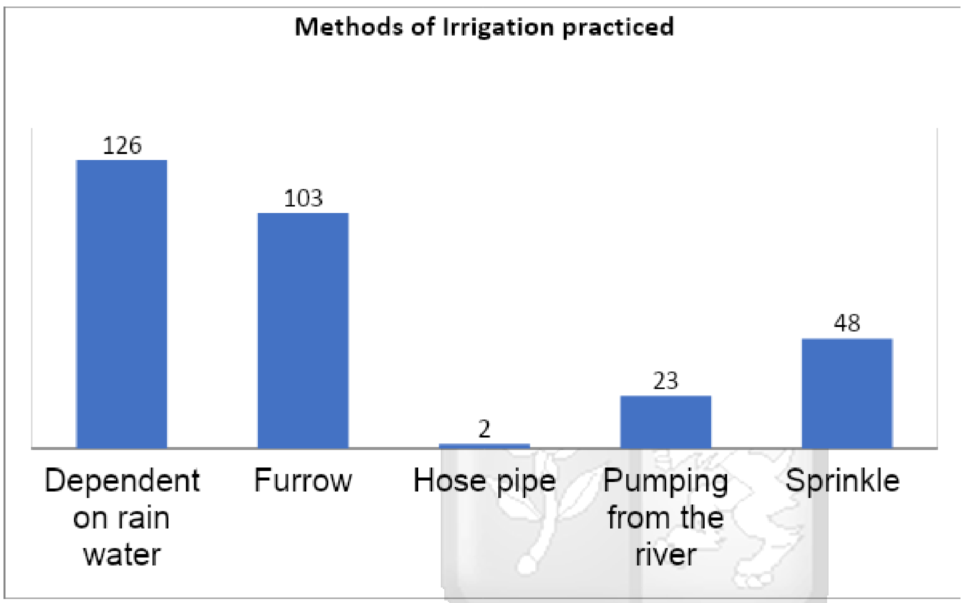



**Figure 4.5 Irrigation methods use by the respondents**

#### 4.5.1.2 Water harvesting techniques

The respondents were asked if they practice any form of water harvesting techniques, 66% of the respondents indicated they do not practice any form of water harvesting, and 34% indicated they practice water harvesting techniques as indicated in the pie chart below.

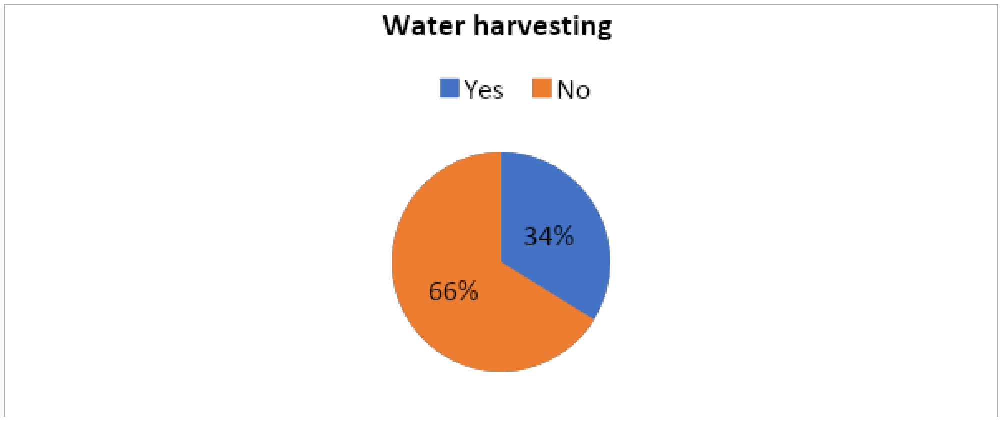



**Figure 4.6 Water harvesting**

### 4.5.2 Correlation Analysis

To investigate the relationship between the water management strategies and banana productivity, a correlation analysis of the various components identified as measuring the variables effectively was carried out using the Pearson product moment correlation coefficient (r). It is observed in Table 4.6.2 below that there is a moderate positive correlation *($R=0.488$, $p < 0.01$)* between use of furrow and banana productivity. This means that increasing use of furrow would lead to increase in banana productivity. The value of correlation coefficient is statistically significant at 5% level of significance. There was a very weak positive correlation between use of furrow and rainwater and banana productivity and the relationship was significant *($R=0.132$, $p < 0.05$).* This means that an increase in the use of furrow and rainwater will lead to increase in banana productivity. Use of rainwater and sprinkle had a negative effect on banana productivity and the effect was significant *($R= -.166$, $p < 0.05$).* An increase in use of rainwater will have a corresponding increase in banana productivity.

**Table 4.15 Correlation Matrix Water Management Strategies**

| Correlations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Banana productivity | Furrow | Furrow & rain water | Hose pipe | Pumping from the river | Pumping & rain water | Rain water & sprinkle | Sprinkle method |
| Banana productivity | r | 1 | .488** | .132* | -0.004 | .318** | 0.055 | -.166** | -0.075 |
| | p value | | 0.000 | 0.022 | 0.947 | 0.000 | 0.338 | 0.004 | 0.192 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Furrow | r | .488** | 1 | -.150** | -0.052 | -.123* | -.129* | -.244** | -0.111 |
| | p value | 0.000 | | 0.009 | 0.370 | 0.032 | 0.025 | 0.000 | 0.054 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Furrow & rain water | r | .132* | -.150** | 1 | -0.019 | -0.046 | -0.048 | -0.091 | -0.041 |
| | p value | 0.022 | 0.009 | | 0.739 | 0.427 | 0.406 | 0.115 | 0.474 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Hose pipe | r | -0.004 | -0.052 | -0.019 | 1 | -0.016 | -0.017 | -0.031 | -0.014 |
| | p value | 0.947 | 0.370 | 0.739 | | 0.784 | 0.774 | 0.587 | 0.805 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |
| Pumping from the river | r | .318** | -.123* | -0.046 | -0.016 | 1 | -0.039 | -0.075 | -0.034 |
| | p value | 0.000 | 0.032 | 0.427 | 0.784 | | 0.494 | 0.195 | 0.556 |
| | N | 302 | 303 | 303 | 303 | 303 | 303 | 303 | 303 |
| Pumping & rain water | r | 0.055 | -.129* | -0.048 | -0.017 | -0.039 | 1 | -0.078 | -0.036 |
| | p value | 0.338 | 0.025 | 0.406 | 0.774 | 0.494 | | 0.175 | 0.538 |
| | N | 302 | 302 | 302 | 302 | 302 | 302 | 302 | 302 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rain water & sprinkle | r | -.166** | -.244** | -0.091 | -0.031 | -0.075 | -0.078 | 1 | -0.067 |
| | p value | 0.004 | 0.000 | 0.115 | 0.587 | 0.195 | 0.175 | | 0.243 |
| | N | 302 | 303 | 303 | 303 | 303 | 303 | 303 | 303 |
| Sprinkle method | r | -0.075 | -0.111 | -0.041 | -0.014 | -0.034 | -0.036 | -0.067 | 1 |
| | p value | 0.192 | 0.054 | 0.474 | 0.805 | 0.556 | 0.538 | 0.243 | |
| | N | 302 | 303 | 303 | 303 | 303 | 303 | 3023 | 303 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | | |

### 4.5.3 Regression Analysis

The objective was to investigate the effects of water management strategies on banana productivity. enhancing banana productivity among smallholder banana farmers in Kirinyaga County, Kenya. Multiple linear regression was performed.

**Table 4.16 Model Summary for Water Management Strategies**

| Model Summary[b] | | | | | |
|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
| 1 | .685[a] | 0.469 | 0.454 | 0.76273 | 1.837 |
| a. Predictors: (Constant), Which ones, Hose pipe, Sprinkle method, Pumping from the river, Pumping & rain water, Furrow & rain water, Rain water & sprinkle , Furrow | | | | | |
| b. Dependent Variable: Banana productivity | | | | | |

The R which is the coefficient of correlation, 68.5% shows there is a strong relationship between the dependent and independent variables. Since this is a positive relationship it suggests that an increase in the independent variables will lead to an increase in the banana productivity which was measured using yield per acre. The coefficient of determination shows that 43.5% of the individual independent variables can be used to predict the yield per acre hence they are good predictors of the model. The adjusted R square is 42.4% which means that the proportion of the dependent variable explained by the independent variables combined in the regression equation is 42.4%.

The overall significance of the model was assessed using ANOVA table as shown in Table 4.6.3.2 below.

**Table 4.17 ANOVA Results for Water Management Strategies**

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 150.410 | 8 | 18.801 | 32.318 | .000[b] |
| | Residual | 170.456 | 293 | 0.582 | | |
| | Total | 320.867 | 301 | | | |
| a. Dependent Variable: banana productivity | | | | | | |

From the table the model is statistically significant *at 5% level of significance, ($F = 32.318$, $p < 0.01$).*

Based on the regression results, water management strategies were statistically significant affecting banana productivity as demonstrated in Table 4.6.3.4

**Table 4.18 Regression Coefficients for Water Management Strategies**

| Coefficients[a] | | | | | |
|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | t | Sig. |
| | | B | Std. Error | | |
| 1 | (Constant) | 6.791 | 0.068 | 99.944 | 0.000 |
| | Furrow | 1.410 | 0.107 | 13.167 | 0.000 |
| | Furrow & rain water | 1.198 | 0.202 | 5.916 | 0.000 |
| | Hose pipe | 0.575 | 0.544 | 1.057 | 0.291 |
| | Pumping from the river | 2.310 | 0.240 | 9.632 | 0.000 |
| | Pumping & rain water | 0.903 | 0.230 | 3.920 | 0.000 |
| | Rain water & sprinkle | 0.179 | 0.140 | 1.278 | 0.202 |
| | Sprinkle method | 0.181 | 0.263 | 0.686 | 0.493 |
| a. Dependent Variable: Banana productivity | | | | | |

Based on the regression results, water management strategies statistically significant affecting banana productivity. Furrow had a positive significant effect (*$t = 13.167$, p value $< 0.01$*) on banana productivity. A unit increase in use of furrow would lead 1.41 increase in banana productivity holding other factors constant. Use of pumping water from the river had a positive and significant influence on banana productivity as given by ($\beta = 2.30$, $t = 9.632$, $p<0.05$). The implication of these findings was that a unit increase in use pumping water from the river would lead to increased banana productivity by 2.30. Use of pumping and rainwater had a positive and significant influence on banana productivity as given by ($\beta = 0.179$, $t = 1.278$, $p<0.01$). The implication of these findings was that a unit increase in use of use of pumping and rainwater would lead to increased banana productivity by 0.179 holding other factors constant.

## 4.6 Banana plant management strategies

### 4.6.1 Descriptive Statistics of Banana plant management strategies

#### 4.6.1.1 Sources of Banana tubers

The table below shows that a very small percentage of the respondents get their banana seedlings from authorized dealers (23%), most of them at 70% recycle from their farms and 32% source from their neighbors.

**Table 4.19 Source of banana tubers**

| Sources of Banana Tubers | Frequency | Percentage |
|---|---|---|
| Recycled from the farm | 213 | 70 |
| Sourced from Neighbors | 98 | 32 |
| Sourced  from authorized dealers | 83 | 28 |

#### 4.6.1.2 Use of tissue culture

From the figure below out of the 302 respondents, only 30% use tissue culture bananas.

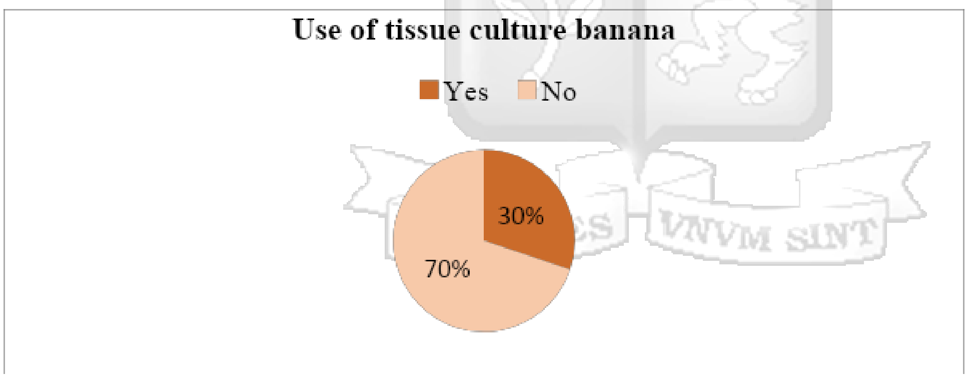



**Figure 4. 8 Use of Tissue Culture Banana**

### 4.6.2 Correlation Analysis

To investigate the relationship between the banana management strategies and banana productivity, a correlation analysis of the various components identified as measuring the variables effectively was carried out using the Pearson product moment correlation coefficient (r). It is observed in Table 4.7.2 below that there is a moderate positive correlation *($R=0.609$, $p < 0.01$)* between use of tissue culture and banana productivity. This means that increasing use of tissue culture would lead to increase in banana productivity. The value of correlation coefficient is statistically significant at 5% level of significance.

**Table 4.20 Correlation Results for Banana Plant Management**

| Correlations | | | | |
|---|---|---|---|---|
| | | Banana productivity | Use of tissue culture | Type of banana plant |
| Banana productivity | R | 1 | .609** | -0.105 |
| | p value | | 0.000 | 0.068 |
| | N | 302 | 302 | 302 |
| Use of tissue culture | R | .609** | 1 | -.251** |
| | p value | 0.000 | | 0.000 |
| | N | 302 | 303 | 303 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | |

### 4.6.3 Regression Analysis for Banana Plant Strategies

The objective was to investigate the effects of banana management strategies on banana productivity. enhancing banana productivity among smallholder banana farmers in Kirinyaga County, Kenya. Multiple linear regression was performed.

**Table 4.21: Model Summary for Banana Plant Management**

| Model Summary[b] | | | | | |
|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
| 1 | .684[a] | 0.468 | 0.464 | 0.75592 | 1.930 |
| a. Predictors: (Constant), Do you use tissue culture banana?, | | | | | |
| b. Dependent Variable: Banana productivity | | | | | |

The R which is the coefficient of correlation, 68.4% shows there is a strong relationship between the dependent and independent variables. Since this is a positive relationship it suggests that an increase in the independent variables will lead to an increase in the banana productivity which was measured using yield per acre. The coefficient of determination shows that 46.8% of the individual independent variables can be used to predict the yield per acre hence they are good predictors of the model. The adjusted R square is 46.4% which means that the proportion of the dependent variable explained by the independent variables combined in the regression equation is 46.4%.

The overall significance of the model was assessed using ANOVA table as shown in Table 4.7.3.2 below.

**Table 4.22 ANOVA Results for Banana Plant Management**

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 150.016 | 2 | 75.008 | 131.269 | .000[b] |
| | Residual | 170.851 | 299 | 0.571 | | |
| | Total | 320.867 | 301 | | | |
| a. Dependent Variable: banana productivity | | | | | | |

From the table the model is statistically significant *at 5% level of significance*, *(F = 131.27, p < 0.01).*

Based on the regression results, banana management strategies were statistically significant affecting banana productivity as shown in the table below.

**Table 4.23 Regression Coefficients for Banana Plant Management**

| Coefficients[a] | | | | | |
|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | t | Sig. |
| | | B | Std. Error | | |
| 1 | (Constant) | 10.037 | 0.168 | 59.886 | 0.000 |
| | Use of tissue culture banana | -1.567 | 0.098 | -16.010 | 0.000 |
| a. Dependent Variable: Banana productivity | | | | | |

Based on the regression results, use of tissue culture had a negative and significant influence on banana productivity as given by ($\beta$ = -1.567, $t$ = 16.010, $p<0.01$). The implication of these findings was that a unit increase in use of tissue culture would lead to decreased banana productivity by 1.567.

### 4.7 Social Economic Factors hindering banana productivity

#### 4.7.1 Descriptive statistics of Social Economic Factors

##### 4.7.1.1 Memberships to Farmer Organizations/Groups

**Table 4.24 1Memberships to Farmer Organizations/group and Training**

| Member of Framers Group and Receiving Training | Frequency (Yes) | Percentage (%) |
|---|---|---|
| Member of a farmer group | 99 | 33% |
| Has received training in the last year | 103 | 34% |

The table above shows only 33% of the 302 farmers is members of the farmer's group and 34% have attended any form of training in banana farming.

##### 4.7.1.2 Sources of Agricultural Information

The section below presents the data analysis relative to the first objective of the study which was to investigate the source of agricultural information and their efficiency.

**Table 4.25 Extent respondents perceive the importance of various listed sources of information**

| Source of information | Not to all | Little extent | Moderate | Great extent | Very great extent |
|---|---|---|---|---|---|
| Farmers Groups | 0 | 0 | 1% | 28% | 5% |
| Cooperatives | 100% | 0 | 0 | 0 | 0 |
| Extension services | 99% | 1% | 0 | 0 | 0 |
| Neighbors farming bananas | 1% | 34% | 62% | 4% | 0% |
| Radio and Television | 3% | 59% | 35% | 3% | 0% |

From the table above the majority of the smallholder farmers rely on Neighbors as a source of information, followed by Radio and Television, those who belong to farmer's groups.

#### 4.7.1.3 Access to Credit and Financing

**Figure 4. 9 Credit/ Financing need in the last one year**

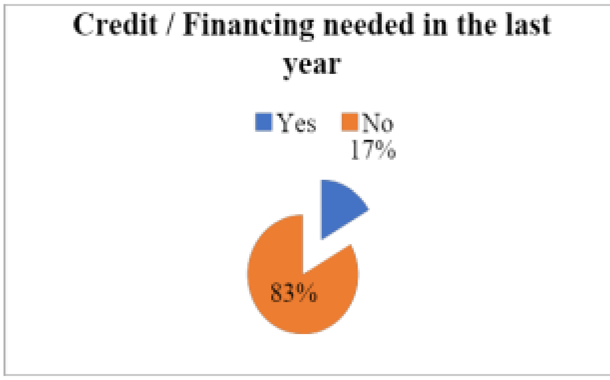



**Figure 4. 7 Access to Credit**

### 4.7.2 Correlation Analysis

To investigate the relationship between social economics strategies and banana productivity, a correlation analysis of the various components identified as measuring the variables effectively was carried out using the Pearson product moment correlation coefficient (r). It is observed in Table 4.8.2 below that there is a weak positive correlation *($R=0.233$, $p < 0.01$)* between years of schooling and banana productivity. This means that increasing years of schooling would lead to increase in banana productivity. The value of correlation coefficient is statistically significant at 5% level of significance. There was a moderate positive correlation between owning an acre of land and banana productivity and the relationship was significant *($R=0.554$, $p < 0.05$).* This means that an increase in the ownership of land will lead to increase in banana productivity. Training on banana farming had a negative effect on banana productivity and the effect was significant *($R= -.680$, $p < 0.01$).* An increase in training on banana farming will have a corresponding reduction in banana productivity.

**Table 4.26 Correlation Matrix Social Economic Factors**

| Correlations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Banana productivity | Years of schooling | A Own (Acres | Land ownership | Training in banana farming | Member of Farmers group | Distance to the nearest source of seed dealer | Distance to the nearest source of fertilizer dealer | Ownership of livestock |
| Banana productivity | R | 1 | .233** | .554** | -0.102 | -.680** | -.611** | .627** | -.195** | .306** |
| | p value | | 0.000 | 0.000 | 0.077 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 |
| | N | 302 | 302 | 302 | 302 | 215 | 302 | 255 | 227 | 179 |
| Years of schooling | R | .233** | 1 | .214** | 0.004 | 0.052 | 0.013 | 0.114 | .144* | 0.087 |
| | p value | 0.000 | | 0.000 | 0.949 | 0.450 | 0.821 | 0.068 | 0.030 | 0.248 |
| | N | 302 | 302 | 302 | 302 | 215 | 302 | 255 | 227 | 179 |
| A Own (Acres | R | .554** | .214** | 1 | -.165** | -0.125 | -.176** | .187** | -0.044 | .261** |
| | p value | 0.000 | 0.000 | | 0.004 | 0.067 | 0.002 | 0.003 | 0.507 | 0.000 |
| | N | 302 | 302 | 302 | 302 | 215 | 302 | 255 | 227 | 179 |
| Land ownership | R | -0.102 | 0.004 | -.165** | 1 | -0.009 | 0.041 | -0.040 | -0.039 | -0.126 |
| | p value | 0.077 | 0.949 | 0.004 | | 0.893 | 0.479 | 0.520 | 0.558 | 0.093 |
| | N | 302 | 302 | 302 | 302 | 215 | 302 | 255 | 227 | 179 |
| Training in banana farming | R | -.680** | 0.052 | -0.125 | -0.009 | 1 | .972** | -.876** | .637** | -0.182 |
| | p value | 0.000 | 0.450 | 0.067 | 0.893 | | 0.000 | 0.000 | 0.000 | 0.051 |
| | N | 215 | 215 | 215 | 215 | 215 | 215 | 173 | 140 | 116 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Member of Farmers group | R | -.611** | 0.013 | -.176** | 0.041 | .972** | 1 | -.913** | .496** | -0.079 |
| | p value | 0.000 | 0.821 | 0.002 | 0.479 | 0.000 | | 0.000 | 0.000 | 0.293 |
| | N | 302 | 302 | 302 | 302 | 215 | 302 | 255 | 227 | 179 |
| Distance to the nearest source of seed dealer | R | .627** | 0.114 | .187** | -0.040 | -.876** | -.913** | 1 | -.422** | .306** |
| | p value | 0.000 | 0.068 | 0.003 | 0.520 | 0.000 | 0.000 | | 0.000 | 0.000 |
| | N | 255 | 255 | 255 | 255 | 173 | 255 | 255 | 218 | 174 |
| Distance to the nearest source of fertilizer dealer | R | -.195** | .144* | -0.044 | -0.039 | .637** | .496** | -.422** | 1 | 0.128 |
| | p value | 0.003 | 0.030 | 0.507 | 0.558 | 0.000 | 0.000 | 0.000 | | 0.087 |
| | N | 227 | 227 | 227 | 227 | 140 | 227 | 218 | 227 | 179 |
| Ownership of livestock | R | .306** | 0.087 | .261** | -0.126 | -0.182 | -0.079 | .306** | 0.128 | 1 |
| | p value | 0.000 | 0.248 | 0.000 | 0.093 | 0.051 | 0.293 | 0.000 | 0.087 | |
| | N | 179 | 179 | 179 | 179 | 116 | 179 | 174 | 179 | 179 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | | | |
| *. Correlation is significant at the 0.05 level (2-tailed). | | | | | | | | | | |

### 4.7.3 Regression Analysis

The objective was to investigate the effects of soil economic on banana productivity enhancing banana productivity among smallholder banana farmers in Kirinyaga County, Kenya. Multiple linear regression was performed.

**Table 4.27 Model Summary for Social Economic Factors**

| Model Summary[b] | | | | | |
|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
| 1 | .460[a] | 0.212 | 0.161 | 0.45231 | 1.757 |
| a. Predictors: (Constant), Distance to the nearest source of fertilizer dealer from residence (km, f28, have you ever attended any training on banana farming? Distance to the nearest source of seed dealer from residence (km , Years of schooling, If Own Land : Title ( Yes/No, Do you belong to any of the following groups? Banana Farmers Groups, Banana Cooperative or any other cooperative or group | | | | | |
| b. Dependent Variable: Banana productivity | | | | | |

The R which is the coefficient of correlation, 46% shows there is a strong relationship between the dependent and independent variables. Since this is a positive relationship it suggests that an increase in the independent variables will lead to an increase in the banana productivity which was measured using yield per acre. The coefficient of determination shows that 21.2% of the individual independent variables can be used to predict the yield per acre hence they are good predictors of the model. The adjusted R square is 16.1% which means that the proportion of the dependent variable explained by the independent variables combined in the regression equation is 16.1%.

The overall significance of the model was assessed using ANOVA table as shown in Table 4.8.3.2 below.

**Table 4.28 ANOVA Results for Social Economic Factors**

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 5.933 | 7 | 0.848 | 4.143 | .000[b] |
| | Residual | 22.095 | 108 | 0.205 | | |
| | Total | 28.029 | 115 | | | |
| a. Dependent Variable: banana productivity | | | | | | |

From the table the model is statistically significant *at 5% level of significance, ($F = 4.143$, $p < 0.01$).*

Based on the regression results, social economic barriers were statistically significant affecting banana productivity as demonstrated in Table 4.8.3.4

**Table 4.29 Regression Coefficients for Social Economic Factors**

| Coefficients[a] | | | | | |
|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | t | Sig. |
| 1 | (Constant) | 7.548 | 0.983 | 7.682 | 0.000 |
| | Years of schooling | 0.030 | 0.016 | 1.901 | 0.060 |
| | Land ownership | -0.190 | 0.227 | -0.836 | 0.405 |
| | Ownership of Livestock | 0.005 | 0.002 | 2.674 | 0.009 |
| | Training in banana farming | -0.372 | 0.268 | -1.390 | 0.167 |
| | Member of Farmers group | -0.282 | 0.528 | -0.534 | 0.595 |
| | Distance to the nearest source of seed dealer | 0.286 | 0.120 | 2.387 | 0.019 |
| | Distance to the nearest source of fertilizer dealer | -0.023 | 0.017 | -1.357 | 0.177 |
| a. Dependent Variable: Banana productivity | | | | | |

Based on the regression results, only two socio economic barriers statistically significant affecting banana productivity. Ownership of livestock had a positive significant effect (*$t$ =2.674, p value < 0.05)* on banana productivity. A unit increase in ownership of livestock would lead 0.005 increase in banana productivity holding other factors constant. Distance to the nearest source of seed dealer from residence (km) had a positive and significant influence on banana productivity as given by ($\beta$ = 0.286, $t$ = 2.387, $p<0.05$). The implication of these findings was that a unit increase in Distance to the nearest source of seed dealer from residence (km) would lead to increased banana productivity by 0.286.

## 4.9: Chapter Summary

This chapter has provided a comprehensive account of how the data gathered was analyzed in order to answer the stated research questions.

The first objective of the study was to establish the influence of soil management strategies on banana productivity. Based on the regression results, soil management strategies effect on banana productivity was statistically significant for example the respondents who used pesticides in their farms had a negative effect on productivity. Farmers who did soil testing 4 to 6 years and 7 to 10 years ago was found to significantly affect banana productivity positively compared. 1 to 3years soil testing did not give positive results as expected in the regression model but on correlation had a weak positive significant. This can be attributed to the small number of 1% respondents who indicated they have done soil testing in the last 1 to 3year, hence the results were not very comprehensive Soil management practices were also found to have a significant effect on banana productivity. Intercropping and mulching had a positive significant effect on banana productivity. This means the effect of intercropping and mulching on productivity was higher than other soil management technology methods i.e. agroforestry and minimum tillage.

The second objective was on the influence of water management strategies on banana productivity. From the coefficient table, it can be deduced that a positive relationship exists between the type of irrigation used and productivity as evidenced by the positive results. Furrow and rainwater as harvesting technique will lead to an increase in productivity of banana than other methods of harvesting water. Pumping from the river had a positive correlation with productivity.

The third objective of the study sought to determine the influence of banana plant management strategies on productivity. The study found a positive relationship exists between the use of tissue culture banana and productivity.

The fourth objective was to identify some of the socio economic factors that hinder adaptation of innovative strategies among smallholder farmers. The study found a positive relationship exists between livestock keeping and productivity. This can be attributed to the benefits of organic manure. There was a significant relationship between those distance to the seed dealer and fertilizer deals and productivity. An indication that access to inputs influences banana productivity

# CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

## 5.1 Introduction

This chapter presented the summary of findings, conclusions, and recommendations of this study on the effect of agricultural innovative strategies on enhancing banana productivity among smallholder farmers in Kirinyaga County. The presentation is in the order of the objectives which were; to examine the effects of soil management strategies on banana productivity, to investigate the effects of water management strategies on banana productivity, to study the effects of banana plant management strategies on productivity and; to analyze the effects of soci0 economic barriers on banana productivity

## 5.2 Summary of findings

The section below presents the summary of findings based on each of the objectives;

### 5.2.1 Soil Management Strategies and Banana Productivity

The first objective of the study was to examine the effects of soil management strategies on banana productivity According to the findings, the study found out that very few farmers do soil testing on their farmers, 83% of the respondents have never conducted soil testing in their farms, an innovative strategy that is key in highlighting what components the soil is missing and that can help improve productivity. From the research, it was evident that farmers who did soil testing 4 to 6 years ago were found to significantly affect banana productivity compared to those who did soil testing seven to ten years ago. Soil testing done 1 to 3years were not found to be significantly positive to productivity as expected in the study. It can be denoted that the number of respondents who had done soil testing with in this period were 1% hence the data was not significantly sufficient to give comprehensive results. Use of fertilizer would lead to increased banana productivity. Although most respondent stated they do not use banana specific fertilizer, they capitalize more on organic fertile that is manure from livestock and mulching. Use of pesticides had a negative and significant influence on banana productivity. From the study very few farmers admitted to using banana specific pesticides on their farms, they mainly concentrated on the main cash crops.

The study through the regression coefficients results shows there is correlations between soil testing and use of fertilizer on banana productivity.

Intercropping and mulching had a positive significant effect on banana productivity compared to other soil management technology methods i.e. agro forestry and minimum tillage. According to the findings, intercropping, mulching, minimum tillage and agro forestry are commonly practice. Agro-forestry is more in Gichugu and Ndia constituencies as they are closer to Mt. Kenya unlike in Kirinyaga Central. Intercropping is very common in areas where coffee, tea, and horticultural crops are grown. It is minimal in Kirinyaga Central where farmers grow tissue culture banana. These findings do not support the findings of (Muthee et al. 2019) who noted the majority of farmers attribute low adoption on the farm management practices due to lack of information high cost and support from extension services. From the study, it is evident that these practices are practiced by the majority of the respondent we reached out to as they are easy practices to adopt and have no costs. The finding of the study on intercropping banana with many crops being grown by farmers is in line with (Ouma, 2009) on the benefit of intercropping among smallholder farmers of food security, poverty reduction, and soil fertility benefits considering the farming land in Kirinyaga has been subdivided and farming land is being constrained by day. Additionally, the findings also relate to (van Asten et al. 2015)who found out that intercropping bananas with coffee help improve production and quality of coffee, helps reduce pests and disease and improve the quality of the soil. This can help us explain where most of the farmers reached out do not use pesticides as disease and pests are controlled. We can also conclude that many farmers growing coffee prefer intercropping with banana because of the benefits.

### 5.2.2 Water Management Strategies and Banana Productivity

The second objective was to investigate the effects of water management strategies on banana productivity farmers in the study area. According to the findings, the study found out that 126 respondents depend on rainwater and do not practice any form of irrigation, 103 respondent practice the furrow method, 23 respondents pump water from the river (those are farmers close to river banks and stream), 48 use the sprinkle method and 2 use Hose pipe method.

Coefficient relationship from the study shows that furrow technique will lead to increase in productivity of banana by 71%, pumping from the rivers will lead to increase in productivity of banana by 58.7% holding and sprinkle will lead to increase in productivity of banana by 28% holding other factors constant.

The findings agree with that (Lee et al. 2012) that those smallholder farmers practicing irrigation experience a shift in household agricultural production and income generation as it enables high yields and a possibility of second cropping season or even year-round production. This can explain why most of the banana farmers are practicing horticulture. The findings further agree with that of (Fandika et al., 2014) on the benefit of irrigation on banana yields where those who use Furrow, pumping from the river and combining it rain, have the banana average yields and gross margin increased.

### 5.2.3 Banana Plant Management and Productivity

The third objective was to study the effects of banana plant management strategies on productivity. According to the findings, the study found out that, majority of the respondents (70%) recycled the banana seedling from their farm, 32% sourced seedlings from their neighbors, and 28% sourced seedlings from the authorized agricultural institution. From the findings, 70% of the respondents use tissue culture bananas.

The findings are in line (Wambugu & Kiome, 2001) which states that the majority of the smallholder banana farmers banana stems come from locally sourced suckers mainly borrowed from neighboring and sometimes recycled from the farms. The research attributes this to lack and high cost of clean material and lack of awareness on available biotechnology as in the case of Tissue culture banana. As based on Muyaga (2009) findings most farmers combine both tissue culture bananas and none – tissue bananas varieties in Kenya mainly because of production and productivity levels, these findings do not go in line with the findings of this study as the researchers discovered those who plant tissue culture bananas hardly mix with other variety mainly witnessed in Kirinyaga central. The cost of production of tissue culture bananas exceeds that of non-tissue varieties according to Muyaga 2009, this explains the reason why most of the smallholder farmers who rely on coffee and tea as the main cash crops give less attention to bananas. The results generally indicate that smallholder farmers in Kenya are yet to realize the full potential of tissue culture banana and how they can maximize the land to increase production.

### 5.2.4 Social-economic factors hindering banana productivity

Aspects analysed included training on banana farming, membership of farmers or cooperative groups, access to information access to credit/financing, and distance to nearest seed and fertilizer dealers. The study found out 34% of the respondents said they have attended a banana farming training and 33% of the respondents indicated that they were members of farmers groups. The study found access to information is mainly from the farmers' group, neighbors farming bananas, and radio and television respectively, in order of impact. It was established from the study that the majority of the respondents did not need financing of their farms with a percentage of 83% saying they did not need credit or financing facilities.

The distance to seed dealers was not very accurate as of the majority source from their farms and neighbors with an average of three minutes' walk. The average distance to fertilizer dealers was 15 minutes. According to the findings, the study concluded that there were few farmers’ groups in the area information; few farmers received training in the last year (2019). The study also concludes that extension services by government bodies or NGOs are and a majority of the farmers rely on Radio and television for new ideas and technology as their first preferred source of information, followed by neighbors who seem to be doing well in banana farming. The finding is in line with (Muthee et al. 2019) which found out that Kenya faces a shortage of agricultural extension officers devoted to promoting scientific farming. The research further states that the current crop of extension workers possesses limited skills in farm management, and the ones with adequate training are few hence cannot be deployed across the country to provide their services to farmers. Also, the aspect of agricultural extension officers specializing in certain crops such as bananas has not been mainstreamed in Kenya’s traditional government extension services (Faturoti et al. 2008)

On access to information, the findings are in line with (Leta et al. 2018) that found out many smallholder farmers are used to engaging in learning about technology or best practices via informal institutions and social-cultural events. In Kirinyaga's case, they rely on neighbors, farmers’ groups and radio, and television as found in the study. These informal sources of information bridge the gap of the extension service that is lacking. Information sources such as Radio and Television offer training on inputs and technologies and are gaining popularity in the County for being reliable and addressing the key problems the farmers are facing.

Training on banana farming is beneficial as per the regression analysis. Those who have been trained have higher yields. These results are in line with (Weyori et al. 2018) who stated that social learning is key for farmers as it helps them cope with this unequal distribution new knowledge of agriculture through communication, observation, public meetings, and group socialization and rural development or embedding it into the local system of knowledge production (Leta et al. 2018).

Land ownership is not an issue in Kirinyaga as most landowners have title deeds and can easily invest in innovative strategies in their farms. The study also found out that most of the Kirinyaga farmers do not require financial services for banana farming. Most of them grow lucrative crops such as coffee and horticultural crops and banana is a third or second crop.

### 5.3 Conclusions of the study

Based on the findings, the study concluded that Innovative Strategies under investigation namely, Soil Management Strategies, Water Management Strategies, Banana Plant Management Strategies have significant influence on banana productivity. The study concluded that these strategies have to be adopted concurrently for better results through diffusion of information which can either be through extension workers, social networks such as farmers' groups. The conclusion are in line with the finding of Petry et al., (2019) who found out that the social networks have significant impacts on how farmers behave and how they can help manage diffusion of innovation in an agricultural set-up.

However, the conclusions contradict conclusion of the study Blazy et al., (2009) who stated that some innovations might be very efficient in some farming contexts and ineffective in others farmers either because of ecological conditions of the farm, financial constraints, knowledge and current farming systems, which vary among farmers, these being key socio economic barriers that might hinder farmers from fully adopting innovative strategies as per the findings of the study.

### 5.4 Recommendations of the study

1. The study recommends that the County Governments, NGOs, Ministry of Agriculture, Ministry of Trade and Industry, the national government collaboration be established with the aim of implementing innovative agricultural Strategies geared towards banana productivity increments.

2. The county Government of Kirinyaga should avail such agricultural extension services that will help facilitate training to farmers and inform them of new techniques in farming. There is also a big opportunity for the private sector to take up the led in training and educating farmers on innovative ideas that can help them boost productivity.

3. The study recommends that Kirinyaga county government and other stakeholders involved, with the welfare and livelihood of Kirinyaga Farmers be in the forefront to ensure banana farmers are well provided for with the right information on soil testing considering a huge percentage of farmers hardly conduct soil testing on their farms

4. Most farmers continue to practice traditional methods of farming. Subdivision of land has caused farming land to reduce by day, hence need to invest more on how farmers can maximize farming space and at the same time increase production banana.
5. Most permanent solutions on water harvesting should be implemented by the county government considering the potential of Kirinyaga as a food basket for the Country. This will help farmers increase their productivity and ensure the supply of food throughout the year for both local consumption and export.

### 5.5 Limitation of the study

The study only focused on Smallholder Farmers in Kirinyaga growing Bananas yet farmers in that area grow other crops, Further studies could therefore focus on wider coverage in order to assess the effects of Innovative strategies on productivity on various crops.

### 5.6 Recommendations for further studies

This study recommends that further studies be done to find out more aspects of soil testing techniques that can be easily and cheaply accessed by smallholder farmers. Tissue culture seems to be losing popularity in the areas, a study to find out why and why adoption of tissue culture technology has been low in the region.

There is also a need to evaluate promising water conservation strategies that will suit the community besides the distributed irrigation systems commonly used by the farmers. Technology may be indigenous to the farming system of origin while being an innovation to the society of adaptation. Currently, the recommendations for water harvesting technologies give blanket recommendations and do not consider inherent differences in soil water holding capacities, soil depth, and texture. Thus, there is a need to carry out research on water harvesting across a range of soils so as to recommend the best technology for each soil type. In addition, there is a need to integrate water harvesting with improved fertility and crop management in order to increase the efficiency of the use of harvested water.

A further research on the role of social networks in influencing innovation should be carried out as farmers are central in the social networks but play very little role in influencing innovation strategies emphasizing on the role of the farmer's group.

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# APPENDICES

## Appendix I: Introduction Letter

Dear Sir/Madam,

I am a graduate student at Strathmore Business School undertaking a Master's degree in Management in Agribusiness. I am undertaking a study titled '**Influence of agricultural innovative strategies on enhancing banana productivity among smallholder farmers in Kirinyaga County**. The research is targeting smallholder farmers like you. I humbly request you to cooperate with the numerator and help answer the questions she will ask to fill in the questionnaire. Your responses and information will be used for this study only and will be held with the utmost confidentiality.

The research study aims to gain a better understanding of innovations being used by banana farmers and to identify gaps if any.

I kindly encourage you to share your honest thoughts during the process.

Thank you for your time and input.

Sincerely,
Esther Kanyi
Strathmore Business School

## Appendix II: Questionnaire

**PART A: FARMERS CHARACTERISTICS**

1) Gender: Female ( ) Male ( )

2) Age ___________________________________________

3) Years of schooling______________________________

4) Where do you get your source of farm income from? (Tick where appropriate)
- ☐ Bananas
- ☐ Coffee
- ☐ Rice
- ☐ Horticultural crops
- ☐ Others ___________________________________

5) Besides farming do you have any other source of Income? ☐ Yes ☐ No

If yes, please specify source of income_______________________________________________

**PART B: FARM INFORMATION AND PRODUCTIVITY**

6) Farm Location: Kirinyaga Central ☐ Ndia ☐ Gichugu ☐

7) How much land do you: A. own? __________ Acres; B. Lease in/rent in? ________ Acres

8) For the land owned do you have a title deed? Yes ☐ No ☐

9) What is the land size of banana plantation? ______________________________________________

10) How many banana plants do you have? __________________________________________________

11) How much banana did you harvest last month? (In Kilograms)? ______________________________

12) What is the average Kilograms of each banana comb? _____________________________________

13) What is the average selling price of banana per Kg? ________________________________________

14) How much on average do you make from your banana farm in a year? ______________________

15 What is the average household income in a year? __________________________________________

16) How much do you make from your farm activities in a month? ______________________________

17) Evaluate the productivity of your banana farm in the last 24 months. (**Tick One**)

- ▢ Declined significantly
- ▢ Declined somewhat
- ▢ Remained the same
- ▢ Improved somewhat
- ▢ Improved significantly

**PART C: SOIL MANAGEMENT**

**A. Soil Testing**

18) When was the last time you did soil testing in your banana farm? (Tick One)

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Less than One year ago | 1 to 3years Ago | 4 to 6 years Ago | 7 to 10 years Ago | Never done any soil test on my farm | I have no idea on soil testing |

19) Do you use to practice the following on your farm? (Tick appropriately)

| **Innovation** | **Yes** | **No** |
|---|---|---|
| Minimum Tillage | | |
| Intercropping | | |
| Mulching | | |
| Agroforestry | | |

**B. Fertilizer and pesticide use**

20a) Do you use fertilizer on your farm?

Yes ▢ No ▢

20b) If yes what type of fertilizer do you use?

- ▢ Crop specific
- ▢ DAP
- ▢ CAN
- ▢ Others (specify)

20c) Do you use animal manure/ compost manure?

Yes ▢ No ▢

20d). Do you use pesticides?

Yes ☐ No☐

21e). If yes specify type of pesticide used_______________________________________________

**PART D: WATER MANAGEMENT**

22a) Do you use any form of Irrigation?

Yes ☐ No ☐

22b) If yes what method of irrigation system do you use?

☐ Drip Irrigation
☐ Sprinkle method
☐ Pumping from the river or other sources

22c) Water Harvesting techniques

Do you practice any form of water harvesting?

Yes ☐ NO ☐

If yes, please specify how________________________________________________________

**PART E: BANANA PLANT MANAGEMENT**

23a) Where do you get you banana cultivars from? _________________________________________

☐ Recycle from the farm
☐ From neighbors with promising banana farms
☐ From authorized agricultural institutions _______________ (Specify)
☐ Others ______________________________

23b) Do you use tissue culture banana?

Yes ☐ No☐

**PART F: SOCIAL ECONOMIC FACTORS**

24) Have you ever attended any training on banana farming? Yes ☐ No ☐

If yes, what kind of training? _______________________________________________________

25) Do you belong to any of the following groups? Banana Farmers Groups, Banana Cooperative or any other cooperative or group? Yes ☐ NO ☐

If yes, please specify which one________________________________________________

26) Access to Information: To what extent do you think the information from the following Groups has helped your farming skills?

| **Access to Information** | **Not at all 1** | **Little extent 2** | **Moderate extent 3** | **Great extent 4** | **Very great extent. 5** |
|---|---|---|---|---|---|
| Farmers Group | | | | | |
| Cooperatives | | | | | |
| Extension services | | | | | |
| Neighbors farming Bananas | | | | | |
| Radio and Television | | | | | |

27) Did you need any credit/ financing in the last year in your banana farm? Yes ☐ No ☐

28) Did you get credit/ Financing? ☐ Yes No ☐

If yes, please specify the source

☐ Bank Loan
☐ Cooperative loan
☐ Farmers group
☐ Other Chamas
☐ Fuliza (Safaricom)
☐ Others (Specify)_____________________________________________________

If no, what are the limitations__________________________________________________?

29). Distance to the nearest source of seed dealer from residence (km) ................minutes of walking time.

30). Distance to the nearest source of fertilizer dealer from residence (km) ...........minutes of walking time

31). Do you have any livestock in your farm ☐Yes No ☐

If yes, please specify which ones_____________________________________________________

## Appendix III: Respondent Consent Form

I Esther Kanyi Kairu from Strathmore University Business School request you to participate in a research study. The purpose of this study is to assess the effects of agricultural innovative strategies on enhancing banana productivity among smallholder farmers in Kirinyaga County.

**Procedure**

To volunteer to participate in this research study and fill a questionnaire regarding the study's objectives.

**Potential Risks**

There are no potential risks to the study participants.

**Benefits to society**

The study will highlight possible areas of improvement that can be tapped by various stakeholders as potential business or research areas in innovation and technology practices that can boost banana production. It will also be a beneficial study to help policymakers come up with proper frameworks to implement innovative strategies across the entire agricultural sector as well as help intensify the success of banana production, value addition and marketing strategies that are lacking.

**Payment for participation**

There are no monetary benefits for participation in this study.

**Confidentiality**

Responses and information will only be used for this study and will be held with the utmost confidentiality. Any identifying information that will be obtained in the study will ensure confidentiality.



**Participation**

Participation in the study is voluntary and you may choose to be part of the study or not.

**Withdrawal and Rights of Research participant**

By volunteering to be part of the research study, you may withdraw any time without any consequences or penalties.

**Signature of Research participant**

I hereby agree to participate in this research study. I have read the information provided for the study as described herein and I have understood the information. I have received a copy of this consent form.

Name of Participant: ____________________ Signature: ______________ Date___________

## Appendix IV: Ethic Approval

Strathmore UNIVERSITY

17th March 2020

Mrs Kanyi, Esther
Ekanyi@gmail.com

Dear Mrs Kanyi,

**RE: An Assessment of Innovative Technologies Used to Increase Banana Productivity Among Smallholder Farmers in Kirinyaga County, Kenya**

This is to inform you that the SU-IERC has reviewed and **approved** your above research proposal. Your application approval number is **SU-IERC0659/20.** The approval period is **17th March, 2020 to 16th March, 2021.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-IERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-IERC within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-IERC within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to SU-IERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

for: Dr Virginia Gichuru,
**Secretary; SU-IERC**

STRATHMORE UNIVERSITY INSTITUTIONAL ETHICS REVIEW COMMITTEE (SU-IERC)
17 MAR 2020
TEL: +254 (0)703 034 000
P. O. Box 59857 - 00200
NAIROBI - KENYA

Cc: Prof Fred Were,
**Chairperson; SU-IERC**

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## Appendix V: NACOSTI License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 943013

Date of Issue: 03/April/2020

### RESEARCH LICENSE

**This is to Certify that Ms.. Esther Kanyi K. of Strathmore University, has been licensed to conduct research in Kirinyaga on the topic: An assessment of innovative technologies used to increase banana productivity among smallholder farmers in Kirinyaga County, Kenya for the period ending : 03/April/2021.**

License No: **NACOSTI/P/20/4580**

**943013**

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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