EVALUATING THE DETERMINANTS FOR THE ADOPTION OF TISSUE CULTURE BANANA TECHNOLOGY BY SMALL-SCALE FARMERS IN NYAMIRA COUNTY, KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented to any other university for consideration of any certification.

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We confirm that the work presented in this thesis was carried out by the candidate under our supervision.

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DEDICATION

This thesis is dedicated to my dear wife Eunice Moraa for her immense support and encouragement, to my children; Deborah, Caleb, and Elvis for their patience and understanding and finally to my dear parents, Wilson Nyang'au and Agnes Nyabeta for laying down the path of my success.

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ABBREVIATIONS AND ACRONYMS

ATPS:	African Technology Policy Studies
FAO:	Food and Agricultural Organization
FSR:	Farming System Research
GDP:	Gross Domestic Product
GoK:	Government of Kenya
IFAD:	International Fund for Agriculture Development
KARI:	Kenya Agricultural Research Institute
KNBS:	Kenya National Bureau of Statics
MoA:	Ministry of Agriculture
NEPAD:	New Partnership for Africa Development
SPAAR:	Special Program for African Agriculture Research
SPSS:	Statistical Package for Social Sciences
SSA:	Sub-Saharan Africa
TC:	Tissue Culture
WB:	World Bank
WVC:	Whole Value Chain

DEFINITION OF OPERATIONAL TERMS

Adoption:	A decision to use tissue culture banana technology after getting the information on its benefits.
Biotechnology:	Refers to any scientific method of technique that makes use of living organisms while or in parts of living organisms to create or modify products to improve another organism (plants and animals) or to cultivate microorganisms for specific applications.
Technology Dissemination:	Educating farmers and other stakeholders to adopt the technology.
Participation:	A process through which farmers and other stakeholders influence decisions on activities.
Farmer's Perception:	An opinion formed by farmers.
Small-scale Banana Farming:	Refers to farming that relies mainly on family labour, and the size of the farm is usually less than 5 acres.
Socio-economic:	Social and economic factors that determine the adoption of tissue culture banana technology.
Stakeholders:	These are farmers, agricultural extension officers, traders, transporters and consumers.
Technology Transfer:	The process by which an innovation is passed through individual channels over time among members of a social system.
Technology:	New knowledge and skills that farmers use in agricultural production.
Tissue Culture:	Refers to the production of new plants (banana plants) from parts of the whole plant.
Tissue Cultured Banana:	Refers to the production of bananas plants from parts of the whole banana plant.

ABSTRACT

To address food insecurity in Kenya, there has been a significant intensification of agriculture to feed the growing population. One of the technologies used is tissue culture (TC) banana technology. However, in spite of the exertions done to disseminate this technology to small-scale farmers, research studies report low adoption rates of the technology. Hence, this study seeks to establish the determinants of the adoption of tissue culture banana technology. The study was carried out in Nyamira North sub-County. The study objectives were; to examine socio-economic characteristics determining the adoption of tissue culture banana technology, to determine benefits accrued from the adoption of tissue culture bananas and to identify constraints farmers face in the adoption of TC banana technology. The study adopted a descriptive study design, and data collection was mainly done through the use of questionnaires, interview schedules and direct observation. Secondary data were collected from published materials, journals and magazines. Qualitative data were analyzed using simple descriptive statistics while quantitative data were cleaned, coded and analyzed using the Statistical Package for Social Sciences (SPSS). Regression analysis was finally used to determine the relationship between variables. Findings indicated that farmers' socio-economic characteristics such as age, gender, marital status, level of education,farming experience, land size and access to credit affect adoption of banana tissue culture technology. They further revealed that sources of information affect farmers' adoption of improved banana farming practices. Farmers identified diverse challenges like lack of capital, TC plantlets, poor extension services and poor infrastructure affect farmers in the adoption of TC bananas. Intervention measures were suggested on how the problems could be addressed to positively enhance adoption of TC bananas. The study recommends formation of savings and credit cooperatives, awareness creation among farmers, improving road network in rural areas, establishing one nursery of TC bananas in each ward and subsidizing the costs of TC banana plantlets. The research findings are expected to be useful to various stakeholders boost the production of bananas and enhance food security.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The banana plant belongs to the family of *Musaceae* and its fruits provide carbohydrates to the consumers. It is the fourth most globally consumed crop after maize, rice, and wheat (Hanumantharaya, 2007). It is used as a staple food in most countries in the tropical and subtropical regions. Banana production worldwide is estimated to be 97.5 million tons per year (FAO, 2011). India is the leading banana producing country in the world followed by Uganda which is the second producer globally (Rarieya and Schmidt, 2009). Most of the production is done in developing countries and accounts for 98% of the global output enhancing food security to these nations (Hanumantharaya, 2007).

The Green revolution offered research and development of technology transfer initiatives that occurred between 1950 and 1960. This increased agricultural production worldwide particularly in the developing world (Jain, 2010). Evidence shows that sound and sustained investment in agriculture science and technology is key to increasing productivity, reducing poverty and fostering economic growth. However, in many developing countries science and technology fail to be included in the national development plans (Jain, 2010).

The government of Kenya, for instance, has made several interventions towards the eradication of extreme poverty and hunger by shifting resources to priority sectors

such as agriculture, health, education, and infrastructure (KARI, 2012). Agricultural biotechnology has been found to offer increased production and incomes in developing countries (Jain, 2010). Among the biotechnologies is Tissue Culture (TC) banana technology. Tissue Culture banana technology is a technique of generating plants from roots, leaves or stems in sterilized conditions and can be produced in abundant numbers. The use of this biotechnology generates disease-free planting materials that help to increase yields and also reduce the time taken for the crop to mature (KARI, 2012).

While developed countries are forging ahead in harnessing the application of biotechnology to increase productivity in their agricultural sectors, the rate of biotechnology adoption in developing countries is slow (Mukandasi and Lusiba, 2006). Despite numerous interventions, campaigns, and strategies by agricultural development partners, few of the technologies advanced have been implemented and adopted by the banana farmers (FAO, 2011).

In Nyamira County, many small-scale farmers own less than an acre of land but fully use it for growing bananas. The constant availability of harvestable bunches of bananas contributes to the year-round food and income security of banana growers (KARI, 2012). Tissue Culture banana technology has been introduced in the County, but 70% of the farmers are slow in adopting it (Nyamira County, 2013). Its adoption was expected to promote banana production to reduce food insecurity and poverty amongst the small-scale banana farmers. This calls for the need to examine factors influencing the adoption of this technology.

The determinants that significantly affect the adoption of the TC bananas are critical because farmers must take into consideration the socio-economic and cultural complexities surrounding adoption decisions. In this regard, it was important to carry out the research and establish why farmers are reluctant to adopt TC bananas. Therefore this study sought to evaluate the determinants for adopting the tissue culture banana technology by small-scale farmers in Nyamira County.

1.2 Statement of the Problem

The use of TC bananas has been introduced to farmers in Nyamira County, but farmers still use traditional banana varieties that are prone to diseases, pest attacks and have low production yields and high post-harvest losses (KARI, 2012). According to Nyamira County development profile, 30% of the small scale banana farmers have adopted TC banana technology. The low adoption rate of the technology has been cited as a cause of concern (Nyamira County, 2013).

The County government of Kisii County is constructing banana factory which needs a continuous supply of bananas to sustain its production. The new factory is expected to see more farmers turning to bananas or raising their output. However, the adoption of TC bananas has been low among the households hence, the need for a study to determine the socio-economic determinants of the adoption of TC banana technology.

Unravelling the reasons responsible for low technology adoption among banana farmers requires that the factors which influence their decisions not to adopt modern agricultural production technologies be identified. This study, therefore, evaluated the determinants affecting the adoption of TC banana technology by small-scale farmers in Nyamira County.

1.3 Justification and Significance of the Study

In Nyamira County, the collapse of the coffee sector due to the drop in coffee prices and a decline in prices of tea gave rise to banana farming to the level of a cash crop (Nguthi, 2007). The shift changed the status of banana to be both a cash crop and a food crop in the County. Furthermore, the increased demand for bananas due to increase in population necessitates an increase in banana production through the use of modern technology such as cultivated TC technology. Therefore this study made significant prepositions on the determinants for adopting the TC banana technology among small-scale farmers.

The study findings may contribute to the literature on adoption while the recommendations may be beneficial to policymakers, farmers, agricultural officers and all stakeholders in banana production. Further, they may be used to enhance adoption by creating awareness on the adoption of TC banana technology in the County. This may help to improve productivity and income-generating capability of bananas through the adoption of TC bananas.

1.4 General Objective of the Study

The general objective of this study was to evaluate the determinants for adopting the TC banana technology by small-scale farmers in Nyamira North sub-County, Nyamira County.

1.4.1 Specific Objectives

i. To examine the socio-economic characteristics that determine the adoption of tissue culture banana technology by small-scale farmers in Nyamira North Sub-County.
ii. To determine the benefits accrued from the adoption of TC bananas by small-scale farmers in Nyamira North sub-County.
iii. To identify the constraints farmers face in the adoption of TC banana technology in Nyamira North sub-County.

1.5 Research Questions

i. What socio-economic factors influence farmers to adopt tissue culture technology in banana production in Nyamira North sub-County?
ii. What benefits are realized are by small-scale farmers from the adoption of cultured tissue bananas in Nyamira North sub-County?
iii. What constraints small-scale farmers face in adopting tissue culture bananas in Nyamira North sub-County?

1.6 Hypothesis

H_0: There is no significant relationship between the socio-economic determinants (age, gender, marital status, level of education, farming experience, land size and access to credit) and the adoption of the TC technology in banana production.

1.7 Scope and Limitations of the Study

The scope of this study was limited to assessing the determinants of adopting tissue culture (TC) banana technology among small-scale farmers. It focused on small-scale banana farmers who had not adopted and for comparative purposes those who had adopted TC bananas, particularly those who owned less than five acres of land. This study faced limitations such as a lack of cooperation by some respondents in filling the questionnaire and demand for cash payments before the interview. Some respondents were reluctant in participating in the study and this was overcome by explaining to the respondents the relevance and purpose of the study and assuring them of their confidentiality and anonymity of the information provided. The other problem was the unavailability of farmers at a particular time to fill the questionnaire. Some farmers were busy with their normal routine activities, and this led to the rescheduling of interviews to a suitable day and time.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section reviews and analyzes literature related to the study highlighting the knowledge that already exists about the topic under investigation. It also provides a theoretical framework that demonstrates the foundation on which the research has been premised as well as a conceptual framework that illustrates the relationship between the study variables.

2.2 Overview of Banana Production

Banana is one of the world's most important crops grown by small and large-scale producers (Kungu, 2007). The economic importance of the banana industry includes generating income from exports, creating employment opportunities for hundreds of thousands of people and providing foodstuff for numerous households globally (FAO, 2011). The industry employs thousands of people in the distribution network and supermarkets worldwide (Veneman, 2013).

The production and marketing of horticultural crops are undergoing continuous change globally to ensure safe and healthy foods. Hunger is Africa's most serious challenge, and over 20% of the world's 840 million hungry people or 98 million are in Africa (KARI, 2012). Increased production of banana in African countries would substantially mitigate the problem of hunger on the continent.

The vast majority of the world's bananas today are cultivated for family consumption or sale in local markets. Table 2.1 below shows countries leading in banana production in the world.

Table 2.1: Banana Production in the World in the year 2013.

Rank	Country	Million Tonnes per year
1	India	29.82
2	China	11.64
3	Uganda	11.23
4	Philippines	9.45
5	Ecuador	8.24
6	Brazil	7.65
7	Indonesia	6.3
8	Colombia	5.27
9	Cameroon	4.94
10	Tanzania	4.08

Source: Veneman, (2013)

In Africa, bananas constitute a significant staple food crop for millions of people. Because banana production takes place the year-round, it provides a valuable food source during the hunger season (Muyanga, 2009). Bananas are therefore critical to food security in Africa despite the fact that most African countries have not embraced modern biotechnology in their production (Veneman, 2013). Banana production in Africa faces challenges that include low-level farm productivity and agricultural inputs, decreasing farm sizes and reduced use of appropriate technologies (Mbabu & Ochieng, 2006). Banana farming and its benefits to the population are now becoming a reality, with more farmers in Uganda realizing the

potential of the crop regarding food security and income generation (Mukandasi & Lusiba, 2006).

Banana farming plays a fundamental role in the economy and food security of Kenya. It is a source of raw materials for agro-based industries, offers employment opportunities and provides a buffering bridge to food provision in times of scarcity between cereal harvests. In Kenya, bananas are grown in Central region (16.5%), Eastern region (9.5%), Western region (8.5%) and Nyanza region (56.1%) (KARI, 2012). The varieties of banana grown fall into two broad categories: cooking varieties that are used as stable food crop alongside maize and the ripening varieties used as fruit when ripe.

Its production in Kenya has undergone three phases of development (KARI, 2012). The predominant East African Highland bananas have been cultivated for over sixty years and are common in all farming systems (Sligh & Christman, 2007). In the early part of the last century, due to increased travel, additional cultivars were introduced with their local names denoting places of origin in the region. The second phase came between the 1950s, and 1970s with the introduction of improved varieties, such as Cavendish, cultivars, and new agricultural technologies including the use of fertilizers, spacing, and pruning among others (Jain, 2010)).

In the late 1990s, the third phase occurred with the introduction of TC bananas. TC technology stemmed out of a need to control diseases and pests that had spread through the conventional practice of planting suckers in all banana-growing regions in Kenya and which had resulted in declined yields (Qaim, 1999). Conventional varieties were found to be prone to diseases like, lack leaf streak, Xanthomonas wilt

of bananas, Fasarium wilt banana streak and banana bunch top disease. This has necessitated the development of tissue culture banana technology to boost banana production worldwide (Kassie *et al.*, 2009). TC is a technique of generating plants from roots, leaves or stems in sterilized conditions. It leads to the production of many plantlets which are genetically uniform (KARI, 2012).

Banana plantations are a monoculture: 97% of the traded bananas come from one single variety *cavendish.* This lack of genetic variation makes banana plants highly susceptible to pests, fungi, and disease. The production of bananas has been declining due to poor farming practices and lack of disease-free planting materials (KARI, 2012). In Kenya, the Ministry of Agriculture (MoA) through KARI introduced TC bananas to help in providing clean planting materials to small-scale farmers hence its adoption was expected to improve its production. (KARI, 2012).

This was done by building the technical capacity of players in the value chain by improving access to clean disease free TC banana plantlets for increased banana production in the late 1990s (KARI, 2012). Most farmers in the Central and Eastern regions adopted TC technology while in Nyamira County 30% of the farmers have adopted it.

In Nyamira County, banana production is a valuable food and cash crop. However, in the last twenty years, there has been a decline in its production due to soil degradation and infestation of bananas with pests and diseases. The situation was threatening food security, income generation and employment in the County. TC bananas was considered to be an appropriate intervention measure to provide quality planting plantlets but its adoption is low (30%) (Nyamira County, 2013).

2.3 Adoption of TC Banana Technology

Adoption in the current study context is the decision to use TC banana technology after getting the information on its benefits (Rogers, 2005). Decision making on whether or not to try TC technology on a household farm depends on the information about the technology and its functional and socio-economic benefits. The information provides a farmer with an opportunity to make an informed decision on the choice of the technology to make. Human beings construct and interpret knowledge differently (Doss, 2001).

Low banana productivity in Kenya is attributed to the failure to use appropriate agricultural technologies by small-scale farmers (Kaaria, 2010). On the other hand, the economic factors that affect farmers' adoption of improved agricultural technologies include farmers' financial situation, change of equipment and uncertainty. Socio-economic factors such as perception about the inefficiency of new technology, peer pressure, lack of role models, and misleading opinion also determine the adoption of new technology (Kassie *et al*., 2009).

Agricultural innovations, diffusion, and dissemination of new technologies are fundamental aspects of the efforts of developing countries to enhance food security and agricultural modernization in particular (Veneman, 2013). It is pertinent to note that more research is essential to understand precisely why improved agricultural technologies are not being adequately adopted. Of immediate concern is the case of banana farmers who are in most instances reluctant to adopt new farming technologies (KARI, 2012).

Kahangi (1999) conducted a study to assess banana production constraints and opportunities in Kenya. The study revealed that TC banana technology has great potential to the farming community in Kenya and has enormous provision for extended local market. However, the study did not involve the determinant for the adoption of TC technology. The current study intends to fill this knowledge gap.

Qaim (1999) conducted a study in assessing the impact of banana biotechnology in Kenya and found that tissue culture (TC) banana technology holds great possibilities for the poor. He categorized Kenyan farmers into three main groups according to farm size: the small-scale, the medium-scale and large-scale farmers. Although beneficial, Qaim (1999) underscores the fact that technology adoption entails a considerable increase in the cost of production. Farmers were required to use farm inputs such as fertilizers and employ labour when planting something that was not required for the cultivation of suckers. Another additional cost component was the planting material itself. The price of a plantlet was Ksh 200 compared with conventional suckers which farmers obtained at a cost of Ksh 50 from neighbours or free from their farms.

To boost adoption, the study recommended the establishment of a micro-credit scheme to provide farmers with enough credit to purchase the plantlets and farm inputs and advocated for the provision of extension service for the removal of market imperfections (Qaim, 1999). However, the present study goes further to examine the socio-economic determinants of the adoption of this technology.

Wambugu and Kiome (2001) undertook a study to understand the benefits of TC-banana technology adoption in Kenya. They found out that farmers did not prefer

TC varieties. This was attributed to the high financial costs involved. They recommended that micro-credit schemes be established to provide funds to farmers with money to buy the plantlets and farm inputs. They further noted that biotechnology has great potential regarding increasing food production and incomes, creating jobs, protecting the environment and conserving biodiversity. To boost adoption, these researchers indicated farmers should be disseminated using inclusive, participatory and interactive ways.

However, some potential constraints to adoption were noted, and these included the need for a broad choice of varieties, limited availability of unused land as well as limited established marketing and distribution systems. Their study focused on the benefits of TC bananas leaving out the determinants for the adoption of TC bananas. This study goes further to examine socio-economic characteristics and other constraints influencing the adoption of TC banana technology.

Mbogoh *et al.* (2002) demonstrated the impacts of introducing and adopting TC technology in banana production in Kenya. The study showed that the adoption of TC- banana technology among smallholder farmers had higher financial returns than that of conventional suckers. They established that, although TC-banana production was more capital intensive, it had higher financial returns than its counterpart suckers. They concluded that the adoption of biotechnology would make a great difference in uplifting the living standards of people not only in Kenya but also in the developing countries. However, they did not evaluate the determinants of the adoption of TC bananas. The current study, therefore, endeavors to fill this knowledge gap.

A study by Nguthi (2007) assessed the impacts of the adoption of TC-bananas among smallholder farmers in the context of HIV and AIDS in rural Kenya. The study was based in the former Maragwa District, in the former Central Province. It demonstrated that continued use of TC-banana technology among smallholder farmers was attributed to the age of the household head, family size, off-farm, livelihood activities and contact with extension officers. The findings indicated that regardless of the HIV/AIDS status of the individual farmer, initial adoption decision was related to capital and security of land tenure. However, the study did not cover other economic factors. This study goes further to investigate both social and economic determinants for the adoption of TC banana technology.

Muyanga (2009) investigated smallholder adoption and economic impacts of TC banana in Kenya. The study sought to find out whether the cultivation of TC-bananas was improving households' income and food security in Embu, South Imenti, Murang'a, Maragwa and Kirinyaga. The results of this study showed that 75% of the farmers had adopted TC-banana technology, but only seven percent (7%) had specialized in its use. Those growing TC-bananas were growing them alongside non-TC-bananas but in separate plots. These findings show that either these farmers are risk-averse and thus not willing to do away with their local varieties in favour of tissue TC-bananas or they are yet to be fully convinced of the superiority of the TC technology. Whereas Muyanga's study sought to determine whether TC improved households, this study investigated the determinants of the adoption of TC banana technology.

2.4 Challenges Facing the Adoption of TC Banana Technology

Several studies concerned with determining the factors associated with the adoption of agricultural innovations by farmers in developing countries have been undertaken. Njeri (2012) observed that even if innovations are widely adopted, they may not have all the intended effects or may sometimes have unintended consequences. In this regard, it is vital to note that the adoption of innovations in agriculture is a complicated multi-level process.

Mapila *et al.* (2011) found that studies about farmers' adoption of new technology highlight the adoption-decision as well as the timing (late or early) primarily regarding the decision-makers' perceptions, not forgetting the inherent characteristics, with "innovators" at one extreme and "laggards" at the other. The researcher asserts that farmers have multiple objectives which include adequate cash income, food security, social security, and a secure resource base (Mapila *et al.*, 2011).

Adoption of improved agricultural innovations may in some instances be a straightforward process. Rogers (2003) advanced that implementation requires adaptation, adjustment, field testing and correction before the technologies can be implemented on a widespread basis. Devries and Toenniessen (2001) in their study of securing the harvest for African crops revealed that the adoption of agricultural technologies is affected by three sets of factors: characteristics of the technology, the features of the farming environment and features of the farmers. They concluded that new technologies stood a better chance of being adopted if compatible with prevalent agricultural practices.

Mapila (2011) noted in a study on rural livelihoods and agricultural policy changes that current conventional agricultural strategies of production, in most cases resulted in economic problems, environmental degradation, and even social problems. He stressed that the efficacy of sustainable farming systems in guaranteeing the socio-economic and ecological sustainability of agricultural practices had been demonstrated. It was also established that, despite the support from the Ministry of Agriculture, farmers are rarely adopting sustainable practices. Such challenges facing farmers include inadequate information given to farmers about available technology. Government initiatives were also found to be failing to encourage adoption due to lack of funding (Mapila, 2011).

2.5 Summary of Literature and Knowledge Gaps

Basing on the literature reviewed, it is evident that a knowledge gap exists for the study. First, a knowledge gap exists on the determinants that influence the adoption of tissue culture technology in banana production in Nyamira County. Although research has been done on various aspects of TC technology, there is little information on the low adoption of TC. On this basis, one of the objectives of the study would help to fill the gap by generating new knowledge on the socio-economic determinants for the adoption of TC technology. Secondly, knowledge of benefits realized from the adoption of TC bananas was missing in the study area. Benefits being the driving force for the adoption, investigations were necessary. Third, knowledge of constraints that farmers face in the adoption of TC bananas was missing as this impedes adoption. Further, knowledge of how small-scale farmers could overcome the challenges and interventions needed to boost adoption was

missing. With this in mind, this study was carried out to bridge the identified knowledge gaps.

2.7 Theoretical Framework

This study used Diffusion of innovations theory which seeks to explain how, why and at what rate new ideas and technology spread (Rogers, 2003). The theory's four elements namely; An innovation (TC culture), communication (how TC is disseminated to farmers), time is taken to adopt and the social system (small scale banana farmers) aided the study to achieve its objectives.

Under the interpretation paradigm of inquiry, it is believed that knowledge is not out there to be discovered, but humans purposely interpret their experiences and create meaning out of it (Rogers, 2005). When farmers attend field day or visit technology demonstration site, they explain what they hear and see. Indeed, human beings are considered autonomous, intentional, active goal-directed, they construct and understand their behaviour and that of their fellow human beings (Ashley, 2009).

According to (Rogers, 2005) five distinctive stages characterize the innovation-decision process: knowledge, persuasion, decision, implementation, and confirmation. Technological innovation is communicated through precise stages over time among farmers (Rogers, 2005). The first is the knowledge stage, where farmers are introduced to the available new technologies of tissue culture and are made to understand their functions. The second is the persuasion stage. At this juncture, farmers may form a hostile attitude to new technology during information exchange. In the third stage, the decision stage, farmers use the information obtained

to commit to technology adoption. The fourth is the implementation stage where farmers put to use or try the technology on their farms. The fifth is the confirmation stage at which farmers confirm the positive outcome of the technology and even introduce their neighbours and friends to these technologies.

In the process of diffusion, farmers consider some essential characteristics of new technology (Rogers, 2005). The first stage is the relative advantage that new technology has over the existing technology. Second, is new technology`s compatibility with current values, tastes, experience, and needs. Third, is the complexity of modern technology to understand and use. The fourth is the degree to which the new technology can be tried on a limited basis. Farmers accept and use technologies with higher trial ability. The fifth is the extent to which the new technology`s results are observable thus farmers prefer technologies with visible results.

2.7.1 Conceptual Framework

This study used the whole value chain (WVC) model (Porter, 1985). The WVC model helps to analyze specific activities through which farming enterprises can create value and competitive advantages. It evaluates the value each particular activity adds to the farming organization for more economic advantage ending with the value of the end product sold. The WVC looks at socio-economic and constraints which lead to the adoption of TC bananas. The success of each component is related to the other, and to successfully adapt tissue culture banana technology in a community; all aspects must be borne in mind. The conceptual framework in Figure 2.1 shows the linkages between various variables and how they relate to achieving

the desired outcome. The farmer must be aware of cultured tissue banana, have the knowledge and make a decision of adopting to plant them. The farmer should be able to mobilize and combine social factors, economic factors and overcome the constraints for a successful decision to or not to adopt the TC banana technology.

The present study investigated the determinants for adopting the TC banana technology as a dependent variable that is closely related to some outcomes; increased production, more income, food security and improved livelihood thus considered to be important factors determining the adoption of TC banana technologies.

The independent variables for this study were three: Social factors (such as awareness creation knowledge and decision making, education level, gender, age and experience), constraints (comprising seedling availability and affordability, growing and orchard management, extension services,infrastructure and marketing) and Economic factors (such as land size, capital and credit facilities, farm input and labour availability).

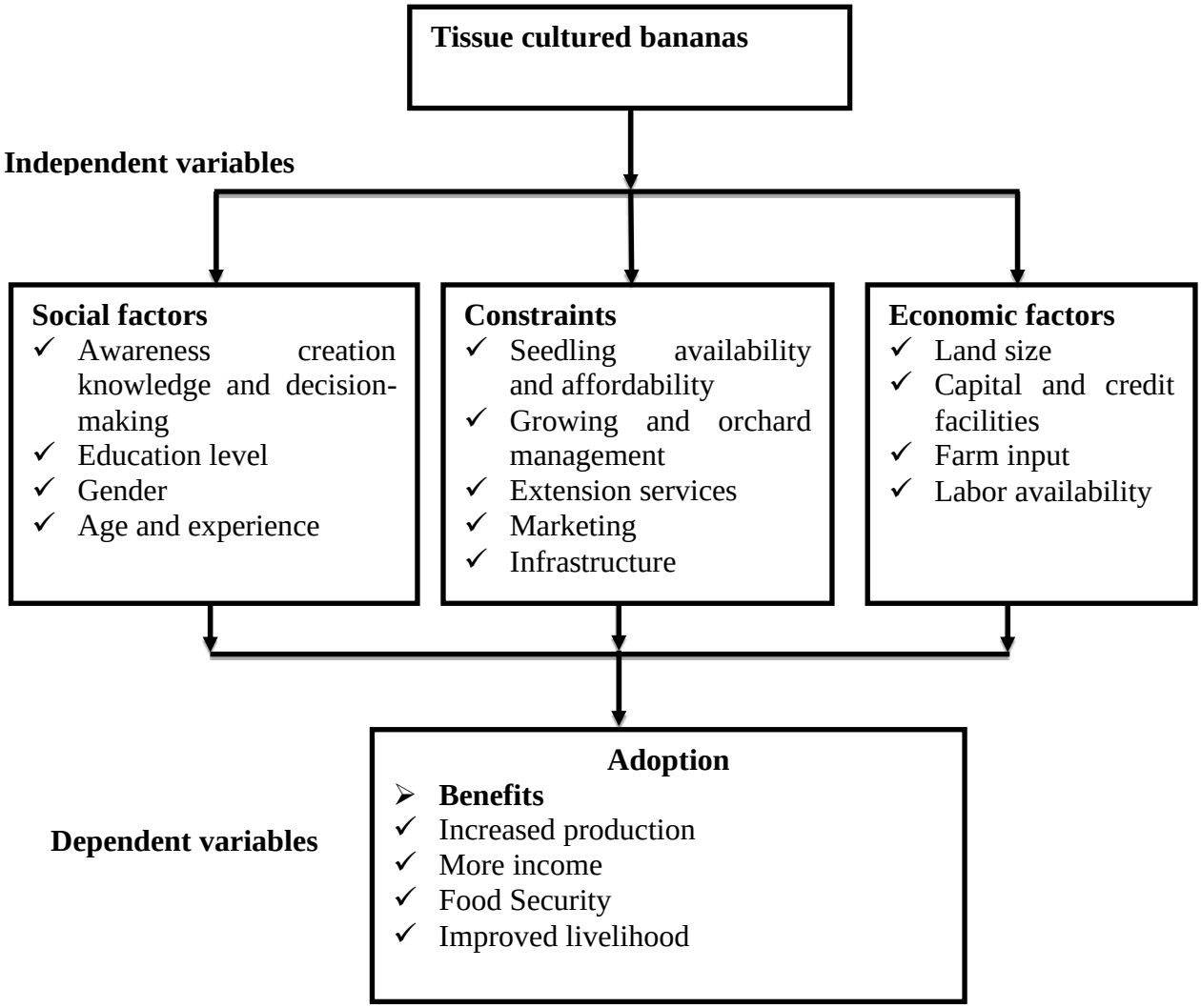

Figure 2.1: Factors Influencing the Adoption of Tissue Cultured Bananas

Source: Adopted and modified from Porter (1985).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research method that was used to carry out the study. It entails the research design, location of the study area, target population, sampling techniques, and data collection tools. It further describes the piloting of the research instruments, validity and reliability testing, and data analysis procedures as well as ethical considerations.

3.2 Research Design

This study used a descriptive research design which is a scientific method that involves collecting data that enables the description of subjects or a situation. Mugenda and Mugenda (2003) argue that any researcher who adopts descriptive design attempts to produce data that is holistic, contextual, descriptive, in-depth and rich in details. According to Kasomo (2015), descriptive research is used when the problem has been well-designed. He observes that the investigation requires formal design and close adherence to defining systems of inquiry to be able to find new facts or collate the existing one.

In the present study, descriptive design was useful in generating information on the underlying determinants that was true and accurate. Two of its methods suited the study, that is, observation and surveys. Observation checklists were used while

surveys helped to answer questions administered through questionnaires and interviews. This made the research instruments to be relevant for the study thus realizing the objectives of the study. The design further made use of both qualitative and quantitative data as obtained from members of the population on various variables.

3.3 Study Area

The study was conducted in Nyamira North Sub county, located in Nyamira County which lies between latitude 00 30' and 0^0 45' South and between longitude 34^0 45' and 35^0 00' East (Figure 3.1). The County covers an area of 899.4 km^2 with a population of 598,252 people (KNBS, 2009). Its population density is 656 persons per km^2. It borders Homa Bay County to the North, Kisii County to the West, Bomet County to the South East and Kericho County to the East.

It is estimated that 52% of the population in this county is involved in the agricultural sector with the largest portion of land (818 km^2) utilized for arable farming, 40.5 km^2 for non-arable activities while 2 km^2 is covered by water mass (Nyamira County, 2013). The major cash crops in the county are tea, coffee, and bananas while food crops are maize, beans, sweet potatoes, vegetables, millet, and sorghum.

Table 3.1: Crop production in the county per year

Crop	Quantity Produced
Maize	1229323 bags
Beans	467935 bags
Bananas	133792 tones
Coffee	49000 tones
Tea	369400 tones
Millet	106350 bags
Tomatoes	5961 crates
Sorghum	3780 bags

Source: Nyamira County Development Profile (2013)

The County is divided into five sub-counties, namely Nyamira South, Nyamira North, Borabu, Manga and Masaba North as shown in Figure 3.1. Table 3.2 below shows the population of Nyamira County per Sub-County.

Table 3.2: Population of Nyamira County

Sub County	Entire population	Male	Female
Nyamira South	157470	75290	82180
Nyamira North	121287	58296	6299
Borabu	115321	57228	58093
Manga	87019	41251	45768
Masaba North	111152	52408	58744
Total	**592249**	**284473**	**307776**

Source: Nyamira County (2013).

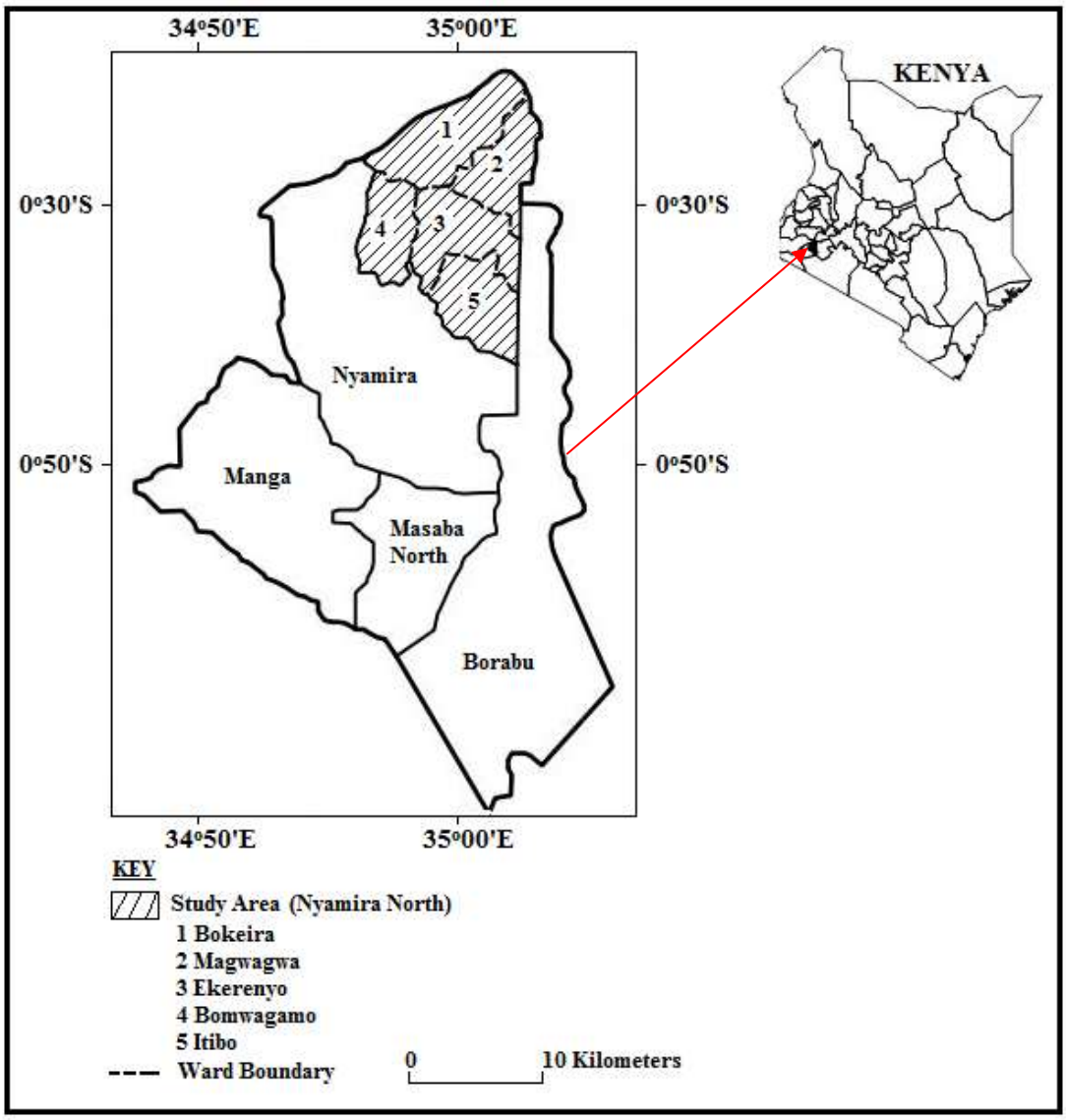

Figure 3.1: The Study Site in Nyamira County

Source: Nyamira County (2013)

Nyamira North sub-County has five wards namely Itibo, Ekerenyo, Bomwagamo, Magwagwa, and Bokeira with a population of 121,287 people (KNBS, 2009) as shown in table 3.3 below.

Table 3.3: Population of Nyamira North Sub-County

Ward	Total population	Male	Female
Itibo	26876	12969	13907
Bomwagama	17156	8106	9050
Bokeira	32446	15601	16845
Magwagwa	18280	8847	9433
Ekerenyo	26529	12773	13756
Total	**121287**	**58296**	**62991**

Source: KNBS (2009)

The sub-County has red volcanic soils which are deep fertile and well-drained. The area has a bimodal pattern of annual rainfall that is well distributed, reliable and adequate for a wide range of crops. Annual rainfall ranges from 1200–2100 mm per annum. The maximum day and minimum night temperatures are typically between 28.7^0C and 10.1^0C respectively, resulting in the normal average temperature of 19.4^0C. These conditions favour the production of bananas. The most considerable proportion of arable land is used for agriculture, and the average holding for small-scale farmers is 1.75 acres (Nyamira County, 2013).

Agriculture is the main economic activity in the sub-County. It is the principal source of food, employment and income for the farmers. It also provides raw materials for agro-based factories like tea factories, coffee factories and banana-based factory at Kisii County. Most small-scale farmers in the County practice

subsistence farming on which they depend for their livelihoods. The decline of price in tea, coffee, and pyrethrum has provided bananas with an opportunity to act as both a cash and food crop. About 7864 small scale farmers plant bananas in Nyamira North sub-county. However, most farmers plant traditional varieties whose production is lower compared with TC bananas introduced through biotechnology (Nyamira County, 2013).

In a view of the importance of bananas in the County, the productivity has been declining over recent years (KARI, 2012). The government of Kenya through the Ministry of Agriculture initiated TC bananas to arrest and reverse the productivity decline in the year 2005. However, about 70% of the farmers have not adopted them. The study was suitable for the area to evaluate the determinants for the adoption of TC bananas.

3.4 Target Population

The study targeted 7864 small-scale banana farmers within Nyamira North sub county who grow bananas for subsistence and as a cash crop. Small-scale banana farming refers to farming that relies mainly on family labour, and the size of the farm is less than 5 acres.

3.5 Sampling Techniques

The study used a simple random sampling technique to collect data from the respondents. This technique was suitable for the study because any member of the population had an opportunity of being selected for the study (Kasomo, 2015). Nyamira North sub county is divided into five wards which have similar aspects

thus providing credible data. This technique was used to collect data from the 5 wards independently each providing twenty (20) respondents for the study. Twenty small-scale banana farmers were randomly sampled from each ward.

Purposive sampling was used to select key informants. It involved the selection of respondents who are rich in the information for the study. In this case, KARI officers and agricultural officers were sampled. The method was suitable for the study because it allowed the acquisition of data in depth. (Kasomo,2015).

3.6 Sample Size

The sample size for a study is dependent on some factors such as the number of variables of the study. Nyamira North sub-county has approximately 7864 small-scale banana farmers (Nyamira County, 2013). The study adopted the formula suggested by Yamane Tora in 1967 (Glenn, 1992). Approximately 100 small-scale banana farmers were sampled after the use of the following formula.

$$n = \frac{N}{1 + Ne^2}$$

Where: ***n***=sample size

N=Total population

e= 0.1 margin error

Computation using the stated formula

n=$\frac{7864}{1+7864(0.1)^2}$ =99.98 (Rounded off to 100)

Therefore n= 100 small-scale farmers. Simple random sampling was employed to select 100 small-scale farmers who participated in the study.

3.7 Research Instruments

Data for this study were collected from both primary and secondary sources. Primary data was collected using questionnaires, interview schedules, and observation checklists. Direct observations were made to capture the non-verbal information relevant to this study and photographs were taken to illustrate the state of banana farming in the study area. Secondary data were collected from published and unpublished sources such as books, journals, KNBS reports, KARI reports, theses, County Government reports and development plans.

3.7.1 Questionnaire

This study utilized questionnaires (Appendix II) containing both open and close-ended questions to be able to capture more information from the respondents. In open-ended questions, respondents were asked open questions and allowed to respond in any way they felt appropriate and with any information they chose to share. In closed-ended questions, respondents were asked questions and choose from a predetermined set of alternatives answers (Pickard, 2013). The closed-ended questions were based on a 5-point Likert scale. The questionnaires were administered to small-scale banana farmers with the aim of eliciting information concerning the socio-economic determinants, benefits, and constraints of TC banana technology adoption.

3.7.2 Interview Schedules

Interviews with agricultural extension officers (Appendix iii) and KARI officials (Appendix IV) were conducted to seek their views on determinants of the adoption of TC banana technology. An interview schedule for this study consisted of seven items covering each of the determinants of the adoption of TC banana technology in Nyamira North sub County. The instrument included the socio-economic factors that determine TC banana adoption, benefits, challenges faced by small-scale farmers and suggested solutions to these constraints.

3.7.3 Observation Checklists

Observations were made during the study to capture important aspects of farming. Among the aspects observed were; banana varieties grown, other crops grown and field practices (Appendix VI). Photographs and notes were taken during the fieldwork, and this formed part of the necessary information obtained from the field that was used to make conclusions of this study.

3.8 Piloting of Research Instruments

A pilot study was conducted before the main study. This was done to validate the research instruments. During piloting, ten small-scale banana farmers were randomly sampled to participate in the study. According to Pickard (2013), 10-13% of the sample size represents the reality of the whole population. Small-scale farmers who were used during the piloting process were excluded from the main study. Piloting helped to assess and develop the research instrument properly (Orodho, 2012).

3.8.1 Validity of Research Instruments

Validity is the extent to which data acquired for analysis essentially characterizes the experience being investigated. It is consequently the measure to which an experiential determination of a notion perfectly signifies that notion (Orodho, 2009).

The study certified that the instruments had content validity which was tested through piloting. The content validity was to ascertain whether the content of the instruments was indicating what it intended to indicate. It was as well to ascertain the precision of the instruments in collecting expected facts aimed at answering the research questions. The study items in the instruments were ascertained to ensure that they were comprehensible and that they brought out the projected data from the selected respondents. The instruments were re-examined for precision and completeness and the level of conformity established as to which items should be incorporated in the final instruments.

3.8.2 Reliability of Research Instruments

Reliability is the degree to which an instrument gives similar answers on repetitive tests. To ascertain the reliability of the instruments, the split-half method technique was utilized. This enabled testing the degree to which items on the tools indicated similar responses. Kasomo (2015) suggests that if items compare significantly with each other, assurance about the reliability of the entire scale is fashioned.

The study determined internal consistency by the use of a reliability coefficient. This entails dividing the test into two parts by even, and odd numbering style and then correlating the responses. If above 80% of respondents give the same answers, the

tests are deemed reliable. The study used Cronbach's' coefficient alpha (α) to test their reliability of scale of the developed items. The benefit of applying the internal uniformity index is that it is approximated after merely one test administration. It consequently evades trouble linked with trying of the research instruments over various phases of time as stated by Pickard (2013).

A correlation coefficient of 0.8 was obtained which indicated the reliability of the instruments. Orodho (2009) states that the drawback of the split-half technique is that, because half of the scores are being correlated with the other half, the coefficient so calculated do not replicate the reliability of the entire instrument. A rectification factor is consequently affected by the calculated correlation coefficient. An added drawback is the numerous ways of grouping the items that go into the test into two halves. Every dividing method gives ways to a different level of correspondence among the two halves, dissimilar reliability coefficients or approximations are got for identical trials (Kasomo, 2015).

3.9 Data Collection Procedures

Data collection started by getting the authority to collect data through an introduction letter from Kenyatta University. A research permit (Appendix IX) and letter of authority (Appendix VII) were then obtained from the National Commission for Science, Technology, and Innovation. Further, the County Commissioner and County Director of Education in Nyamira County gave authorization letters for the research to be conducted in the County (Appendix x and xi) respectively. A pre-visit was conducted at KARI offices and sub-County agricultural offices to establish a rapport with the key informants in their respective offices before the actual data

collection. Data collected were recorded in notebooks to be used in data analysis and discussion of the findings.

3.10 Data Analysis Procedure

The analytical process was vital for qualitative and quantitative data. Data analysis was done to answer the research questions of the study. Data collected was sorted, classified, coded and tabulated for its analysis. It was then summarized and categorized according to the common themes. The Statistical Package for Social Sciences (SPSS v20) software aided the analysis because it was appropriate for the analysis of management-related attitudinal responses.

Descriptive statistics were employed to analyze the data. Tables, charts, and graphs were used to present the results for easy understanding and analysis. Tables were used to summarize responses for further analysis and comparisons. The results were presented on tables, pie charts and bar graphs.

Qualitative data were analyzed by summarizing the information gathered, categorizing and coding them into themes and presenting them in a narrative form. Data presentation was done in the form of tables and figures.

Hypothesis testing to determine the significant relationship between the socio-economic determinants and adoption was done through regression analysis at a 95% level of significance. Regression analysis is a set of statistical process for estimating the relationships among variables. This analysis was appropriate for the study because it includes analyzing several variables when the focus is on the relationship

between a dependent variable and one or more independent variables (Pickard, 2013). Multiple regression equation was adopted as follows;

$$Y=\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where **Y**= Adaptability of tissue cultured bananas

$\beta_1 \ldots \beta_3$= Coefficients of determination

X_1 = Social factors

X_2= Benefits of TC adoption

X_3= Constraints of TC adoption

ε = Error term

3.11 Ethical Considerations

The researcher obtained an introductory letter from Graduate school at Kenyatta University introducing him to the National Commission for Science Technology and Innovation (NACOSTI) to get a research permit. After that, a letter from the county department of Agriculture was sought to approve the study to be conducted in Nyamira North sub County. Before any data could be gathered, the participants were made aware that their responses were confidential and that the information was purely for academic purposes. In the analysis and dissemination of results, some measures were to be taken to ensure privacy, anonymity, and confidentiality of participants. Besides, all the respondents willingly agreed to participate in the study in which the names of the participating respondents were not to be used.

CHAPTER FOUR

FINDINGS AND DISCUSSIONS OF THE STUDY

4.1 Introduction

This section presents data, results, and discussions of the findings on the determinants of the adoption of tissue culture banana (TC) technology by small scale farmers in Nyamira North sub- County, Nyamira County, Kenya.

4.2 Response Rate

Response rate refers to the proportion of the sample that participated as intended in all the research procedures. Orodho (2009) asserts that a return rate of more than 70% is credible for the generalization of the study findings. The response rate in the current study is presented in Table 4.1. The result indicates that a total of 100 respondents participated in data collection. The respondents participated in the study up to the end. This indicated that the response was credible enough to allow analysis and generalization of collected data, thus leading to meaningful conclusions and recommendations.

Table 4.1: Response Rate

Respondents	Questionnaire administered	Return rate	(%)
Small scale banana farmers	100	100	100
Total	**100**	**100**	**100**

Source: Field data, 2016

4.3 Social Determinants for Adopting TC Banana Technology

As part of its first objective, the study sought to evaluate the social determinants of tissue culture banana technology adoption among small-scale farmers in Nyamira North sub-County. For the purposes of this research, the social determinants comprise age, gender, marital status, level of education and farming experience. Findings for each variable are presented in the subsequent sub-sections.

4.3.1 Age Distribution of Respondents

The age distribution was considered in an attempt to establish how it affected the adoption of banana improvement technologies. Table 4.2 shows the age distribution of sampled small-scale farmers in Nyamira North sub-County.

Table 4.2: Age Distribution of Banana Farmers who adopted TC

Age Group	Frequency	Percentage (%) Adopted
Below 25 years	07	11%
26 – 35 years	21	34%
36 – 45 years	28	45%
46 – 55 years	32	08%
Above 56 years	12	02%
Total	100	100%

Source: Field data, 2016

The study revealed that the age of the farmers was an influencing factor in the adoption of banana improvement technologies. Findings showed that 45% of the respondents (aged between 36- 45 years) had adopted tissue culture banana technology. They own their land and can make independent decisions, unlike the youth who depend on their fathers. However, 2% of the farmers aged above 56 years had adopted TC technology. This is because they are old and resistant to new

changes. These findings were found to be in line with the previous studies conducted by Kaaria (2010) which revealed that age influences adoption decisions. Kaaria further observed that young educated farmers were more willing to innovate and adopt new technologies that reduce the amount of time spent on farming.

However, a study carried out by Munyanga (2009) notes that TC improves the livelihood of farmers, but that the factor of age does not play any significant role in its adoption. Kassie *et al.* (2009) confirmed that economic motivation motivates TC adoption and further points out that age is a contributing factor in that farmers older than 36years were reluctant to adopt new technologies.

4.3.2 Gender distribution in Banana Farming

Table 4.3 shows the gender distribution of the sampled small-scale banana farmers in the study area.

Table 4.3: Gender Distribution of Banana Farmers

Gender	Frequency (f)	Percentage (%)
Male	42	42%
Female	58	58%
Total	100	100

Source: Field data, 2016

Data in table 4.3 indicate that 58% of the respondents were female while 42% were male. This implies that in the study area, the majority of the people involved in banana production were females. Qaim (1999) asserts that women are more involved in farming activities than their male counterparts. Although women are considered

to be the leading food producers, they, however, lacked access to and control over the means of production such as land ownership, monitoring of labour and adoption of new farming technology (Doss, 2001; Ellis, 2000). This was mainly attributed to the prevailing land tenure systems which culturally favour men in inter-generational property transfer and gender roles.

4.3.3 Gender roles and Decision Making

The study investigated gender roles and decision making of banana farmers. Table 4.4 shows the results obtained from 58% of the female respondents.

Table 4.4: Gender roles and decision making

	Frequency (f)	**Percentage (%)**
Male are landowners	25	43%
Farming decisions are made by males	19	33%
Only males inherit the land	14	24%
Total	**58**	**100**

Source: Field data, 2016

According to the findings, 43% of the female respondents acknowledged that male own land. They attributed this gender disparity to land tenure insecurity which lowers their investment in banana improvement technologies. The female respondents argued that high level of insecurity in property rights interfered with their desire to adopt TC banana technologies. Although the respondents revealed that women were involved in farming activities, they were not decision-makers over farming resources and agricultural activities.

The results further depict that 33% of the sampled female respondents confirmed that decisions are made by males. They argued that they had no control over resources in banana production and thus could not make decisions on their own. This attribute was basically due to the inability of most women to own land for farming which predominantly belonged to males.

This study shows that male spouses are the final decision-makers regarding farming activities to be undertaken on family land. The findings demonstrate that gender roles had an impact to play in the investment of banana improvement technologies. Although Interviews with household heads revealed that women were involved in farming activities, they were not decision-makers over farming resources and agricultural activities. Women play a fundamental role in food production and make a substantial contribution to household food security (FAO, 2009).

Kaaria (2010) noted that traditionally, most women do not own land for farming. In the study, the author argued that historically, women access to land in most African cultures was based on status within the family and involved right of use, not ownership. Muriithi *et al.* (2007) in their study found out that although married women had user rights over their husbands' land, the husbands in most cases have more exclusive rights over the land's disposal.

4.3.4 Level of Education

This study sought to investigate whether the respondents' level of education was a determinant in the adoption of TC banana technology. Table 4.5 shows the level of education of the sampled small-scale banana farmers in the study area.

Table 4.5: Level of education of Banana Farmers

Level of Education	Frequency*(f)*	% Adopted
Never went to school	27	11%
Primary	46	20%
Secondary	17	37%
Post-secondary	10	32%
Total	100	100%

Source: Field data, 2016

The study findings indicated that the 37% and 32% of the farmers who had adopted TC had high level of formal education. Interviews with key informants confirmed that adopting tissue culture banana technologies in most cases required some level of education for the technologies to be efficiently and effectively adopted. Formal education affects the adoption of banana improvement technologies because it enhances the farmers' logical capability to obtain as well as process and understand information that was considered relevant for the adoption of banana improvement technologies.

The fundamental role of farmer's educational attainment regarding agricultural technology adoption of tissue culture banana technology is far and widely acknowledged (Kaaria, 2010).

Consequently, formal education significantly affected the farmers' decisions to adopt banana improvement techniques. According to an earlier study conducted by Caswell *et al*. (2001), education was found to affect technology adoption as well as

increased farm productivity levels. In their study, they revealed that education created a psychologically favourable mental attitude for the effective and efficient acceptance of new technologies.

4.3.5 Marital Status of Banana Farmers

This study sought to investigate the marital status of banana farmers in Nyamira North sub county to establish how it influences tissue culture banana technology adoption. Data on the marital status of respondents are as shown in Table 4.6 below.

Table 4.6: Marital Status of Farmers Adopting TC Bananas.

Marital status	**Frequency*(f)***	**(%) Adopted TC**
Married	65	46%
Single	10	16%
Widowed	16	21%
Divorced	4	10%
Separated	5	07%
Total	100	100%

Source: Field data, 2016

From the interviews conducted with the respondents, findings revealed that 46% of the married farmers adopted TC technology while 7% of the separated farmers adopted. This indicates that marital status significantly affected the adoption of TC banana technology. The study findings contrast the findings of Nguthi (2007) which concluded that, regardless of the marital status of the individual farmer, the adoption decision was related to capital and security of land tenure.

4.3.6 Banana Farming Experience

This study investigated the farming experience of small-scale farmers as a determinant for the adoption of tissue culture banana technology. The following information was obtained as illustrated in Figure 4.1

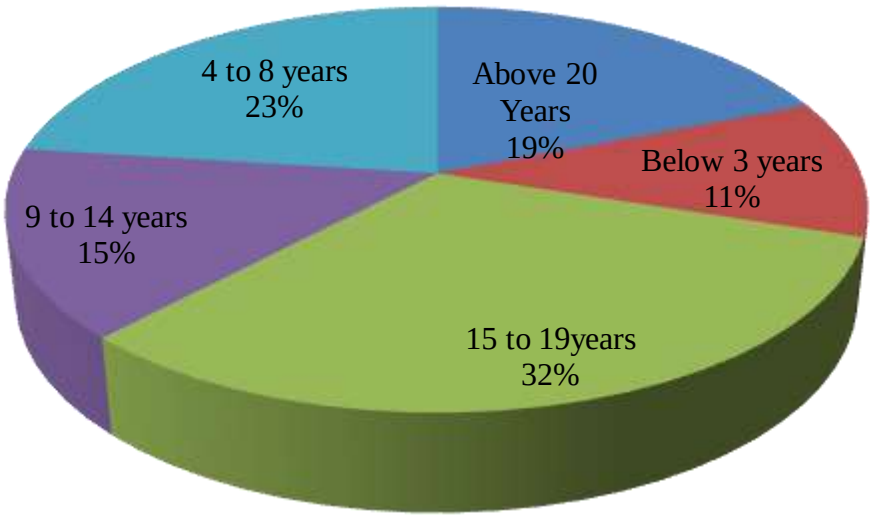

Figure 4.1: Banana Farming Experience

Source: Field data, 2016

The study showed that 11% of the farmers had practised farming for less than three years while 19% had practised it for over twenty years. Further investigations were done to determine whether banana farming experience influenced TC adoption. Table 4.7 gives the results of the findings.

Table 4.7: Banana Farming Experience and Adoption

Farming Experience	TC adopted	Not adopted TC	Total
Below 3 years	9%	2%	11%
4-8 years	15%	8%	23%
9-14 years	4%	11%	15%
15-19 years	6%	26%	32%
Above 20 years	3%	16%	19%
Total	**37%**	**63%**	**100**%

Source: Field data, 2016

It was observed that banana farming experience influenced TC adoption and that experienced farmers were not willing to adopt TC banana farming. The study observed that 9% out of 11% of farmers who had practised banana farming below three years were willing to adopt. The study further depicts that 15% out of 23% of the farmers with an experience of 4-8 years were willing to adopt the technology. Respondents acknowledged that they were aware of the tissue culture banana technology but had not adopted it.

4.4 Economic Determinants for Adopting TC Banana Technology

Farming resources are the key economic components on which banana farming is anchored on. This study identified the following economic determinants for TC banana technology adoption: land size, access to credit, farm input and labour availability.

4.4.1 Land Size

Growing of bananas entirely relies on the size of the land on which to plant crops. In the current study, investigations were done to evaluate the extent to which the size of land affects farmers in the adoption of TC bananas in Nyamira North sub County. Data obtained on farm size owned by banana farmers are shown in Table 4.8. below.

Table 4.8: Land Size

Size in Acres	**Frequency*(f)***	**Percentage (%) Adopted**
Less than 1 acre	54	16%
2 – 3 acres	36	23%
4 – 5 acres	06	34%
More than 5 acres	04	27%
Total	**100**	**100%**

Source: Field data, 2016

Based on the study findings, farmers whose land size was 4-5 acres had the 34% of adoption followed by those with more than 5 acres (27 %). Majority of the farmers had subdivided their land into small portions growing different types of crops such as maize and beans, tea, napier grass, pineapples, sweet potatoes, Irish potatoes, avocadoes, passion fruits as well as bananas. This was attributed to the high population density in the area leading to land fragmentation making it uneconomical for farming. Besides, comprehensive land tenure systems in the study area encouraged land fragmentation thus hindering the effective adoption of banana improvement technologies. This negatively affected the adoption of TC bananas. These results confirm the findings of the study by Kassie, *et al.* (2009) which found

that those farmers with large farms were likely to pay close attention to adopting improved farming technologies.

Plate 4.1: Mixed Farming; Bananas, Coffee and Napier grass

Source: Field data, 2016

Plate 4.1 shows a mixed farm where the farmers choose to plant many crops. It can be observed that the farmer has intercropped bananas with coffee and napier grass. According to the KARI officials, mixed farming stresses the plants as they scramble for nutrients. Further, disease control becomes a challenge as the intercropped plants may harbour pests or carriers of a particular disease which may be problematic to control.

Farmers in the study area practiced intercropping because they did not have adequate land to plant each crop separately. Land-size contributed to limiting the

adoption of banana improvement technologies, because it required large farm areas. Consequently, banana farmers with inadequate farmland could not adopt these technologies.

4.4.2 Access to Credit to Boost Banana Farming

Access to credit was vital for households who engaged in banana farming as it would aid farm input purchase. It was equally important to gather information on whether or not respondents had access to credit to establish how the farmers' economic characteristics affect the adoption of TC banana technologies. Small-scale farmers required money to cater for the costs of planting which include buying of fertilizers, TC plantlets, pesticides, labour for digging holes, watering and weeding. Approximately the cost of planting 450 TC plantlets per acre was Ksh.76,000 (seventy-six thousand shillings). To investigate whether farmers accessed credit facilities, the following results were obtained as shown in figure 4.2.

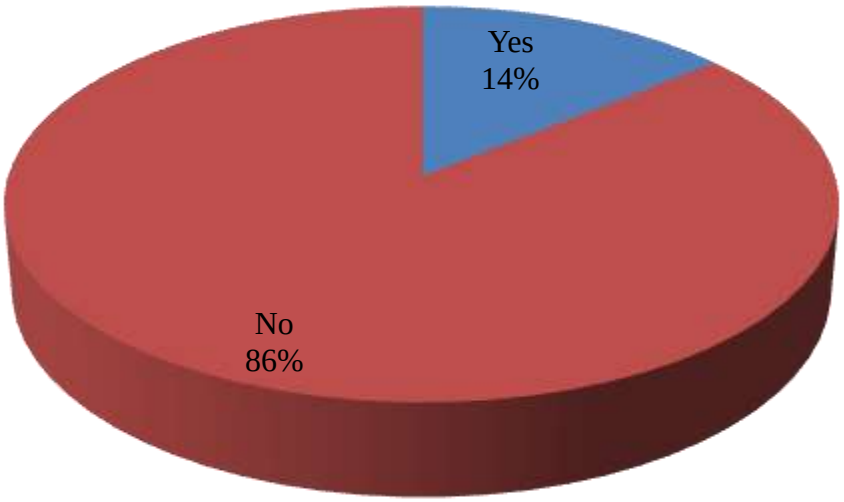

Figure 4.2: Farmer's Access to Credit to Boost Banana Farming

Source: Field data, 2016

Figure 4.2 shows that 86% of the banana farmers in the study area had no access to credit facilities while 14% of the respondents had access. The study found out that some farmers did not have the ability to access credit facilities. This was attributed to the fact that commercial banks did not grant loans to small scale farmers due to lack of security or ability to repay. Adoption of banana improvement agricultural technologies required resources for implementation and this was limited by inaccessibility to credit facilities.

Interviews with Agricultural Extension Officers revealed that access to credit enabled and facilitated farm households to have the capacity to acquire the recommended agricultural inputs. Despite the importance of access to credit,

findings from the study indicated that majority of farm households lacked access hence they could not get enough capital to enable them adopt TC bananas.

Banana farmers revealed that there was a tendency for farmers to apparently take agricultural innovations if they had access to credit which would enable them to afford the purchase of farm inputs, afford labour payment and obtain other relevant resources required for the adoption of banana improvement technologies. Findings in this study correspond with the results of Sharma *et al.* (1997) which concluded that the ability of a household to bear risks was to a greater extent dependent upon the capacity to access credit facilities.

4.5 Benefits of the Adoption of Banana Tissue Culture

The second objective of the study focused on the benefits of TC banana technology hence the need to find out what the respondents considered as the benefits associated with the adoption of TC banana technology. Table 4.9 below summarizes the benefits.

Table 4.9: Benefits of Adopting TC Banana Technology

Benefit	SA	A	N	D	SD	%
Increased yields	59	39	2	0	0	100
Increased income	44	45	8	3	0	100
Short Growth Period	43	27	18	5	7	100
Pest and disease resistant	39	29	8	9	15	100

Source: Field data, 2016
Key: SA - Strongly Agree, A – Agree, N - Neutral, D – Disagree, SD - Strongly Disagree

4.5.1 Increased Yields

Findings revealed that the adoption of TC banana technology increased farm yields. Data obtained shows that, 59% strongly agreed that TC banana yields were more than the conventional bananas. 39% agreed to the statement while 2% were neutral and lacked an opinion about the comparison of the farm yields from modern technology bananas and that of traditional ones.

Interviews with small-scale farmers who had adopted TC bananas revealed that TC bananas increase farm yields. They confirmed that TC banana variety is high yielding, disease-resistant, matures faster and attracts good returns to farmers. The study revealed that the annual yield of TC bananas per acre is 10 tonnes compared with 5 tonnes of indigenous bananas. The proponents of TC bananas attributed increased yields to uniform growth and development of the crop, shorter harvesting period and higher bunch weight. Further, they asserted that due to uniformity in growth, the management of field practices is convenient for the farmer hence harvesting can be done at the same time to meet the market demands. These findings were in agreement with Qaim (1999) who asserted that TC farming gives more yields.

4.5.2 Increased Income

The study revealed that TC banana technology increased income compared with traditional varieties. Data obtained during the study indicated that 44% strongly agreed that TC banana yields were more revenue generation than the typical

bananas. 45% of the sampled respondents agreed with the statement while 8% were neutral and lacked an opinion about the comparison of the farm yields from TC bananas and that of traditional ones. A minority 3% disagreed with this statement.

Small-scale farmers who had embraced TC banana technology asserted that TC generated more income compared with traditional varieties. They confirmed that the cost of a bunch of TC banana ranges from Ksh 1000 - Ksh 1500 while that of traditional varieties vary from Ksh 350 - Ksh 700. Increased income was associated with a uniform and short growing period of the crop enabling many bunches of bananas to be harvested at the same time. In addition, the size and weight of banana bunches are higher compared with traditional varieties which did not mature uniformly. Marketing of large volumes of harvested bunches of TC bananas enabled the farmer to have more income. These findings are in agreement with the study by Wambugu and Kiome (2001) who asserted that TC farming is a reliable source of revenue for farmers.

4.5.3 Short Growth Period of TC bananas.

Another benefit which resulted from the adoption of TC bananas was its growing period. According to the study findings, 43% strongly agreed that TC banana took a shorter period to grow than the traditional bananas. 27% agreed to this statement while 18% were undecided. In addition, 5% did not agree with the statement while 7% disagreed strongly.

Findings indicated that TC bananas grow very fast and mature early because they have short stems and do not require staking. Contrary to this, traditional suckers have long stems thus needs staking or else they break. Investigations from small-scale farmers who had adopted the technology showed that TC bananas produce fruits faster within 340 days compared to 420 days which conventional bananas take. The findings of this study are consistent with those of Wambugu and Kiome (2001) who noted that TC plants grow faster hence are advantageous as cash crops for farmers.

4.5.4 Pest and Disease Resistant

Pest and disease resistance was as another benefit of TC bananas. Based on the data obtained from sampled farmers, it was found that 39% strongly agreed that TC banana was more resistant to pests and diseases than the traditional bananas, 29% agreed to the statement, 8% were undecided while 15% strongly disagreed with this statement.

Respondents who had adopted TC bananas confirmed that with proper care and field hygiene especially during planting, TC bananas are pest-free and disease resistant. Small-scale farmers asserted that banana production was declining in the study area because most farmers planted traditional varieties which are prone to diseases that affect the yields and lead to big losses. The study revealed that bacterial diseases, fungal diseases, nematodes, and weevils affected the production of bananas in the study area.

However, those with divergent opinion attributed it to the care and maintenance of TC banana from the time of transplanting to maturity. They said that TC banana farming is labour intensive and needed a lot of attention. Similarly transplanted plantlets also required treatments at earlier stages thus making it difficult to determine if they were more disease resistant as compared to the indigenous bananas that required none of this. The findings from the majority support the results by Wambugu and Kiome (2001) who concluded that TC plants are pest and disease resistant.

4.6 Constraints Facing Farmers in Adoption of TC Banana

The third objective of this study addresses the constraints faced by farmers in adopting TC banana technology. Several constraints face the adoption of banana improvement technologies by farmers in Nyamira North sub County. Therefore, the study sought to establish the constraints to adoption of banana improvement technologies. Table 4.10 shows constraints faced by farmers in the adoption of TC banana technology by small-scale farmers in Nyamira North Sub County.

Table 4.10: Constraints Facing Farmers in Adoption of TC

Constraints	SA	A	N	D	SD	Total %
Lack of finance to buy inputs	80	15	5			100
Culture and traditions	0	30	50	20	10	100
Poor infrastructure	40	50	5	5	0	100
Other practices that meet farmer's needs	0	40	45	10	5	100
Decision-making at household	30	45	10	15	0	100
Highinputs requirements	20	60	15	5	0	100
Labour intensity	5	50	30	10	5	100
Risk avoidance mechanism	0	20	60	15	5	100
Lack of TC seedlings	10	60	20	10	0	100
Poor agricultural extension services	20	55	20	5	0	100

Source: Field data, 2016

Key: SA - Strongly Agree, A – Agree, N - Neutral, D – Disagree, SD - Strongly Disagree

The above challenges facing farmers in adopting banana tissue culture technology in Nyamira North sub-County are discussed below.

4.6.1 Lack of finance

The study findings revealed that lack of finance posed a major challenge in the adoption of TC bananas. This was demonstrated by 80% of the sampled farmers who agreed strongly that "Lack of finance to buy inputs" was the greatest constraint that they faced during the implementation process of TC banana technology, 15% agreed with this statement while 5% were undecided about this statement. It was

revealed that to adopt TC banana technology, some capital was needed to purchase TC plantlets, farm inputs like fertilizers and payment of labour for field works. Evidently, commercial banks hardly lend money to small-scale farmers because of the perceived aspect that they may fail to repay (Nnadi and Akwiwu, 2007).

Findings also revealed that poverty affected effective and efficient adoption of banana improvement technologies. It affected the farmers' ability to access agro-inputs as well as other resources required to support banana farmers in technology adoption.

4.6.2 Culture and Traditions

The study presumed that some small-scale farmers feared to adopt TC bananas because they were genetically modified through laboratory conditions. According to the information obtained, their culture and tradition did not allow them to grow genetically modified crops. The respondents confirmed that the speculations that genetically modified crops posed health threats to consumers played a negative role in the adoption of TC bananas. It was noted that 30% of the sampled respondents were in agreement with the statement that "Culture and traditions" barred them from embracing TC banana technology. 50% were undecided, 20% disagreed while 10% strongly disagreed with this statement. Respondents said that culture and traditions were constraints and attributed the fact that TC bananas were genetically modified and may affect their health. This instilled fear amongst them hence they feared to adopt the new technology.

4.6.3 Poor Infrastructure

Poor transport systems were also cited to be a challenge faced during the implementation process of TC banana technology with 50% of the responses agreeing on this statement, 40% strongly agree to the statement and only 5% disagreeing.

Findings from the study observations revealed that large volumes of bananas had to be transported over long distances, and stored for a considerable period after harvesting. Perishability of bananas during post-harvest handling was in this regard said to be a major constraint affecting the adoption of improved agricultural technologies. Results from the findings indicated that substantial losses occurred due to poor storage and transport infrastructure. Wambugu *et al.* (2002) assert that post-harvest losses are attributed to poor roads.

Farmers revealed that inadequate access to markets for agricultural produce affected the adoption of banana improvement techniques. Furthermore, vehicles and motorcycles used as means for transporting bananas produce are open, unrefrigerated and therefore, unsuitable. This, therefore, affected the quality of the harvested banana products and hence reduced the price. Plate 4.2 below shows ripe bananas rotting in a heap due to lack of ready market.

Plate 4.2: Post-harvested bananas rotting in a heap
Source: Field data, 2016

4.6.4 Other Practices that Meet Farmer's Needs

Some respondents stated that they failed to implement TC banana technology because they did not rely on banana farming only for their livelihoods. This is because most of these farmers practiced mixed farming by growing different types of crops, kept some animals like cows and a few carried some business. The study findings depicted that other practices that meet farmer's needs play a role in the adoption of TC bananas. The investigation demonstrated that 55% of the sampled farmers agreed with this statement, 30% were undecided while 15% disagreed with this statement. This is because most small-scale banana farmers do not rely on

bananas. They practiced mixed farming for subsistence and carried domestic businesses to generate income for their families.

4.6.5 Household Level Decision-making

Decision-making at the household level was also considered as a major constraint when implementing TC banana technology. This was attributed by the household head and decision making at a family level on whether to adopt the technology or not. Findings showed that 45% of the sampled farmers agreed with this statement, 39% strongly agreed to this statement while 15% disagreed with it. This might have been as a result of the decision-making responsibility being mandated to the household heads, that is, the husbands or men in the family. Women were involved more in banana farming, but they were not the ones who made final decisions for the family especially in regard to the adoption of new farming technology.

4.6.6 High Inputs Requirements

In a bid to determine the extent to which input requirement constrained farmers in adopting TC bananas, respondents acknowledged that farm inputs were required to fully realize the benefits of TC bananas. Study findings indicated that the majority of farmers (60%) agreed that TC banana technology required high inputs for proper implementation, 20% strongly agreed, 15% disagreed while 5% strongly disagreed. This finding could be explained by TC's need for the application of fertilizers and

pesticides which were expensive to most farmers. This made them not to adopt TC bananas hence resolved to remain using indigenous conventional suckers.

4.6.7 Labor Intensity

The study tried to investigate how labour impedes the adoption of TC bananas. The study revealed that the adoption of TC required some labour which included; proper preparation of land, digging of holes, application of manure or fertilizer, planting, watering, weeding, de-suckering, de-leafing, harvesting, and marketing. Farmers explained that among the field management practices, watering was the main labour requirement especially after planting. Further, the caring process of new TC banana seedling was considered labour-intensive. Respondents argued that they feared to adopt TC bananas because of the vigorous labour demand practices. From the findings of this study, 50% of the sampled respondent agreed that TC banana technology was labour-intensive while some 30% were undecided about this statement.

Plate 4.3 shows a plantation whose owner explained that scarce human resource was a major challenge in the adoption of banana improvement technologies. Findings from this study indicated that the shortage of human resource regarding labour had affected farmers' adoption of banana improvement techniques.

Plate 4.3: Uncultivated Banana Farm in Nyamira County

Source: Field data, 2016

4.6.8 Risk Avoidance Mechanism

Other farmers were not willing to adopt TC technology as they used this as a risk-avoidance mechanism. Respondents claimed that some farmers feared to adopt the technology to avoid risks which may be accrued from the failure of the technology in case they did not comply and put into practice all the necessary orchard management required in the implementation of TC banana technology. During the study, 20% of the respondents were in agreement with this statement, 60% were undecided about it, 15% disagreed while 5% strongly disagreed with it. Small-scale farmers who had not adopted the TC technology claimed that they feared being

involved in a new technology whose failure to implement successfully would lead to big losses.

4.6.9 Lack of TC seedlings

Lack of TC seedlings for farmers was cited as another constraint that hindered farmers from adopting TC bananas. Findings from this study indicated that the cost of TC banana plantlet was a major challenge to most farmers. Whereas the conventional suckers were readily available, TC plantlets were purchased at a cost of Ksh.200 per a seedling. Besides, the farmer had to incur transportation costs from KARI Kisii center in the neighbouring county because it is the main supplier to Nyamira County. The study observed that the majority of the sampled farmers 60% agreed with this statement, 10% disagreed, 20% were undecided while 10% disagreed. Actually, most respondents argued that TC plantlets were expensive and they not readily available within Nyamira County. This posed a major hindrance to the adoption of TC banana technology.

Plate 4.4 shows banana plantlets ready for transplanting. From the observation, it can be deduced that they require a lot of care during the period they are in nurseries and when they are being transported to the farms. Much attention is needed to ensure that all plants are in good health after transplanting. They also require being watered regularly to ensure that all the plantlets survive and grow into a banana plant. Ignorance after transplantation will mean losses and thus the extra cost to the farmer

something majority of small scale farmers in the sub County who are low income earners fear.

Plate 4.4: Banana Plantlets in a Nursery Ready for Planting
Source: field data, 2016

Plate 4.5: Banana Plantlets in a Nursery
Source: Field data, 2016

Plate 4.5 shows the early stages of TC banana plantlets. They need to be grown in a well controlled environment which is only attainable under a greenhouse.

The study investigated how farmers obtained TC plantlets for planting. The following results were obtained as shown in figure 4.5.

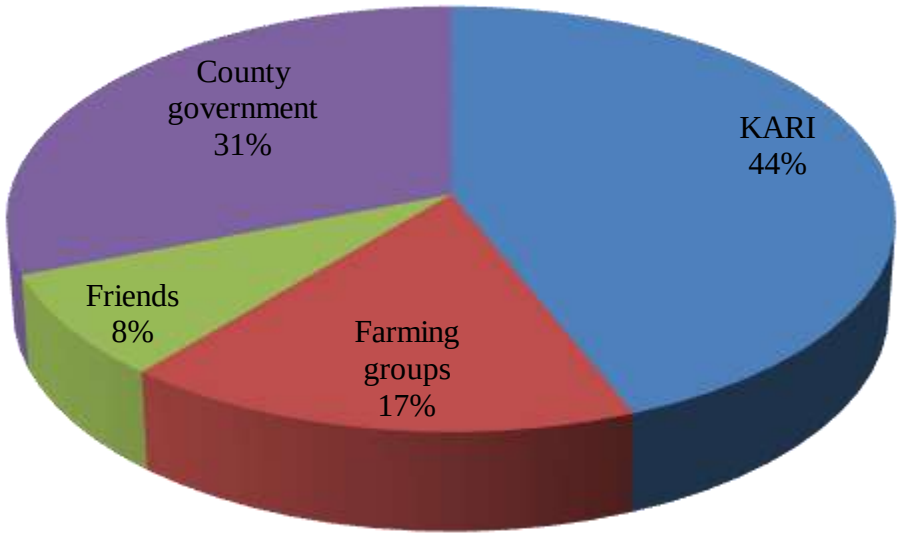

Figure 4.3: Source of Banana Plantlets
Source: Field data, 2016

The findings of this study showed that majority (44%) of small scale banana farmers in Nyamira North sub County got banana plantlets from KARI Centre in Kisii County that serves both Kisii and Nyamira counties. The distance constraint limits farmers' access to tissue-cultured banana plantlets. Some 31% of farmers said that

they acquired TC banana plantlets from County government agricultural improvement programme.

The sampled farmers stated that the county initiative to supply TC banana plantlets was a significant step towards the implementation of banana improvement technologies despite the challenge of regular supply. They further argued that the county supply was not reliable and many farmers who relied on it missed the supply. Some 17% of the sampled farmers said that they acquired their plantlets from farming groups organized and managed locally.

According to the sample, 8% acquired banana plantlets from friends where they uproot banana suckers and replant them in their farms. According to KARI officials uprooting and replanting TC bananas stresses them, and hence the plants do not cope with their new environment.

Plate 4.6 shows some suckers uprooted waiting for planting.

Plate 4.6: Uprooted Banana Suckers

Source: Field data, 2016

4.6.10 Poor Agricultural Extension Services

Poor agricultural extension services were also cited as a constraint facing banana farmers. While 55% agreed with this statement, 20% strongly agreed, and the other 20% were undecided about this statement. In this regard, it was reported that there was inadequate dissemination of agricultural research findings to the end users due

to the lack of adequate funds and this affected the adoption of banana improvement technologies. It was further reported that the investigation concerning agricultural modernization was predominantly funded and supported by foreign development partners like world vision.

Farmers argued that the absence of adequate mechanisms to facilitate provision as well as supporting dissemination of technologies and innovations to the end-users affected adoption of banana improvement technologies. This was attributed to inadequate dissemination of research outcomes concerning banana improvement technologies.

Plate 4.7: Banana Plantation where Tissue Culture has not been Adopted
Source: Field data, 2016

Plate 4.7 shows a banana plantation in Nyamira North sub County where adoption of banana improvement agricultural technologies was not adopted. The owner of the above farm explained that inadequate information about banana improvement techniques was the major factor for not using any.

4.7 Farmers Suggested Interventions

Banana farmers were asked on measures they felt could address challenges in adopting TC banana technology. Table 4.11 gives the responses.

Table 4.11: Actions Suggested by the Farmers for Overcoming Challenges

Actions for overcoming challenges	Frequency (f)	Percentage (%)
Advancing credit facilities	31	31
Formation of Farmers' Groups and Associations	16	16
Supporting Research and Development	13	13
Implementing advancements by extension workers	12	12
Improving road network	10	10
Implementing disease control measures	10	10
Attending Workshops and Seminars	8	8
Total	**100**	**100**

Source: Field data, 2016

The study revealed that due to lack of capital for adopting the new farming technology, 31% of the farmers suggested "Advancing credit facilities" to enable banana farmers access loans and other types of funding for TC banana technology adoption. They also suggested that the agricultural sector was underfunded, especially in research and development. In addition to that, they advocated the need

for the government to encourage development partners to avail adequate funds for agricultural development.

Some 16% of the farmers suggested that there be “Formation of Farmers' Groups and associations” to aid in increasing access to information concerning the care of TC banana plantlets as well as the access to plantlets for planting. Training courses should be made available to extension workers to equip them with skills for effective dissemination of information regarding improved agricultural technologies. The effectiveness of agricultural extension agents in encouraging agricultural technology uptake was limited by inadequate training and knowledge on the actual farm operations and problems. Thus, it was important to note that training is a paramount component affecting the adoption of banana improvement technologies. Several training of trainers’ courses and monitoring tours should be organized for agricultural extension workers to promote effective technology exchange and transfer.

A section of farmers (13%) suggested that a committee “Supporting Research and Development” be created to enhance research activities relating to TC banana farming techniques. It was also revealed that most of the tissue culture techniques and information generated through research was not getting down to the intended end users due to the lack of proper information flow from the researchers to the farmers. It was also observed that the lack of communication contributed to the poor adoption of these technologies.

Community development workers in the study area emphasized the need for increased sensitization of the banana farmers to create awareness regarding the

benefits of adopting banana improvement technologies. They further added that there was an urgent need to support research on diseases affecting the plantations of banana farmers, especially the *banana bacterial wilt* – the disease that majority of the respondents claimed was responsible for the destruction of banana plantations and thus causing losses to the farmers.

Another 12% of the respondents suggested that "Implementing advancements by extension workers" this could facilitate the diffusion of the technology among banana farmers. There is a need for the government to set up demonstration farms to improve scaling up of the improved agricultural technologies and to increase their impact. On-farm trials and demonstrations create meaningful avenues to present as well as show cases of the effectiveness of the banana improvement technologies to farmers. Outstanding technologies identified from on-station and on-farm trials can be further evaluated in demonstration trials. The events carried out would act as useful tools to show cases the effectiveness of improved production technologies. This could convince the banana farmers to adopt them.

Farmers also suggested that provision of proper and adequate infrastructure was essential for marketing as well as critical for bulk and perishable products like bananas. A good rural road feeder network was proposed, particularly for active production, transportation, and marketing of the harvested banana produce. Poor roads increase transport costs, and this has a bearing on final net margins.

A section of the farmers (10%) suggested that 'Implementing disease control measures" by the government and other stakeholders could ease the menace of pest and disease associated with banana production. Besides, it was also revealed by

some farmers that there is need for the Government to support disease control measures to overcome the challenges affecting banana farmers in the adoption of banana improvement technologies was paramount. Some of the farmers emphasized the need for government to provide farmers with knowledge and information regarding techniques of controlling the banana wilt and other banana diseases.

According to the findings, 8% of the sampled respondents suggested that 'Attending Workshops and Seminars' could ease the burden of TC banana farming adoption. Findings showed that most of the knowledge and information concerning banana improvement technologies generated through research were not getting to the intended end-users, who, in this regard, are the banana farmers. Community outreach programme needs to be designed to sensitize the banana farmers and motivate them on adopting improved agricultural technologies.

They proposed the programmes to include rural radio and video shows. The outreach programme should provide information and easy-to-learn ways of training the banana farmers about improved agricultural technologies. The videos can also be translated into a local language which could be used efficiently by trainers to teach and convey important extension messages to the banana farmers

4.8 Regression Analysis

A regression analysis was conducted to establish the relationship between the social determinants and the dependent variable. The results are presented in Table 4.12 below.

Table 4.12: Regression Analysis Table

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	*Std. Error*	*Beta*		
(Constant)	3.661	0.510		7.178	0.000
Social economic factors	0.131	0.060	0.140	2.021	0.045
Benefits of TC adoption	0.135	0.057	0.150	2.031	0.043
Constrains of TC adoption	-0.128	0.059	-0.138	-1.983	0.048

Dependent Variable: TC banana technology adoption

Applying the regression formula: $\mathbf{Y=\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon.}$ The established model for the study was; $\mathbf{Y=3.661 + 0.131X_1 + -128X_2 + 0.135X_3 + \varepsilon.}$

The regression equation above established that taking all factors into account (Social-economic factors, Benefits of TC adoption, and Constraints of TC adoption) constant at zero TC banana technology adoption was 3.661. The findings further indicate that taking all other independent variables at zero, a unit increase in the Social-economic factors would lead to a 0.131, a unit increase in the Benefits of TC adoption would lead to 0.135, and a unit increase in the Constraints of TC adoption would lead to -0.128.

From the above regression equation, it is clear that Socio-economic factors, Benefits of TC adoption, and Constraints of TC adoption significantly influenced TC banana technology adoption as their P-values were less than the hypothetical P-value of 0.05 hence the entire variables were statistically significant. Constraints of TC adoption was observed to significantly influence TC adoption as the P-value 0.048 since it was slightly lower than the P-value of 0.05 as indicated by the above figures in Table 4.13.

Table 4.13: Model Summary

Model	R	R Square	Adjusted R Square	Std. The error of the Estimate	*Change Statistics*	
					R Square Change	F Change
1	0.213	0.045	0.038	0.711	0.045	3.210

Based on the findings in the above table; the value of adjusted R squared (coefficient of determination) was 0.038, an indication that there was a variation of 3.8% on the Social-economic factors, Benefits of TC adoption, and Constraints of TC adoption at 95% confidence interval. The study also established that there was a positive relationship between the socio-economic determinants and TC adoption as shown above by the correlation coefficient (R) of 0.213.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The chapter has four major sections. The first section presents a summary of the study objective. The second section gives a summary of the key findings presented in line with the objectives of the study. The third section gives the conclusion of the study while the last section provides the major recommendation of the study to enhance adoption of TC banana in Nyamira North sub-County, Nyamira County.

5.2 Summary

The general objective of the study was to evaluate the determinants for adopting the tissue culture banana technology by small-scale farmers in Nyamira North sub Country, Nyamira County. The specific objectives which the study intended to achieve were: to examine the socio-economic characteristics that determine the adoption of TC banana technology by small-scale farmers, to determine the benefits accrued from the adoption of TC banana by small-scale farmer, and to identify the constraints small scale farmers face in the adoption of TC banana technology in Nyamira North sub-County. This summary is principally guided by the above research objectives.

5.2.1 Socio-economic Determinants

Objective one of this study was to examine the socio-economic characteristics that determine the adoption of TC technology by small-scale farmers in Nyamira North

sub county, Nyamira County. The study depicts age, gender, education, marital status and farming experience as social characteristics while land size and finances the economic characteristics.

The study revealed that the age of the farmers was an influencing factor in the adoption of improved technologies. Small-scale farmers who were 46 years old and above were not willing to adopt because they were conservative and resistant to change towards adopting new technology in banana farming. The findings demonstrated that farmers who were 45 years and below were willing to adapt TC technology since the majority of them were educated and could easily cope with the dynamics in agricultural production to adopt despite the constraints they faced.

Formal education influenced the adoption of TC bananas because it enhances farmers' logical capability to obtain and understand relevant information considered for adoption. Sampled small-scale banana farmers were characterized by different education level such those who had primary level education, secondary, post-secondary and those who never went to school. Educated small-scale farmers were expected to understand TC banana technology and had more information in relation to its production. This is because education increases awareness of TC banana field management practices and can apply the appropriate orchard management.

Gender relations within the banana farming households regarding production factors such as labour, availability of land and capital significantly affected TC banana adoption among farmers in Nyamira North sub-County. According to the findings, women have been known for a long time to have domestic responsibilities in the household and not make a final decision on how land is to be utilized. Majority of

the people involved in the banana production were women although males owned the land. This phenomenon was mainly attributed to comprehensive land tenure systems which culturally favour men in inter-generational correctly transfer and gender roles.

Those women who had power and ability to take action on farm use were observed to be widows while others had their husbands working away from home but still relied on their husband's final word to implement any new farming activity. This practice was basically due to the inability of most women to own land for farming which predominantly belonged to males. This gender disparity attributed to land tenure insecurity and this in return lowered their investment in banana improvement technologies.

The findings on the marital status showed that it significantly affected the adoption of TC banana technologies. Respondents in the study area asserted that it was the married society member who was found to be actively attending workshops and participating in other related community development initiatives concerning agricultural modernization. Further, the study revealed that farmers who had been married for a longer period were not willing to adopt while those married for a shorter period of time eager to adopt TC bananas.

Banana farming experience significantly influenced the adoption of TC bananas. It was also noted that a group of farmers who were at old age had also been practising banana farming for a long time although some of them had not adopted culture banana technology. Contrary to that farmer who had practiced farming for less than four years was willing to adopt despite the challenges they faced.

Further, the study identified economic factors for adoption to be; land, credit facilities, farm inputs, and labour. Land was considered to be a major determinant of TC banana technology adoption. Although farmers who were 35 years old and below were willing to participate in adoption, issues on land tenure hindered them. This was attributed to failure by their parents to give them full ownership of subdividing the land to them because they feared that the youth may sell the land once they were given full ownership. The findings affirm that this led to low adoption of new technology introduced in the area. According to the agricultural officer in the study area, land was a scarce resource in the region. This forced farmers to practice intercropping thus setting aside approximately less than one acre of farmland for banana production.

The study further investigated farmers' access to credit for financial support to purchase the required farm inputs. It was revealed that finance was a significant determinant in the adoption of TC bananas. Respondents explained that adoption of banana improvement technologies required resources in order to be implemented and this was limited by inaccessibility to credit facilities. Farmers argued that, with enough capital, it could be easier for them to get farm inputs, labour for good farm management and meet marketing expenses.

5.2.2 Benefits of the Adoption of Banana Tissue Culture

Objective two of the study was to determine the benefits accrued from the adoption of TC banana technology by small-scale farmers. In a bid to determine the benefits, small-scale banana farmers who had adopted TC technology identified the following benefits: increased yields, whereby farmers could harvest 30-40 tons per hectare a

product which is twice the yields of the traditional varieties. Respondents also confirmed that TC bananas take 340 days to mature compared to 420 days which conventional bananas take to mature.

Farmers revealed that with good orchard management, TC bananas produced more yields than the indigenous species. Apparently increase in produce implies that farmers could sell more translating to the generation of more income. This attribute was due to their shorter growth period and distinctive features of being disease-free.

Another distinctive benefit that emanated from the study on the adoption of TC is a pest and disease-resistant plants. Respondents acknowledged that good orchard management does not only lead to increased yields but also enables banana plants to be clean and free from pests and diseases. Further, the study depicts that TC bananas have a shorter growth period. As proof, KARI officers asserted that many TC plantlets could be cultivated within a short time and take a short period to mature. In a nutshell, the above benefits contribute to the promotion of food security.

5.2.3 Constraints Facing Farmers in Adoption of Banana Tissue Culture

Finally, the third objective was to identify the constraints that farmers face in the adoption of TC bananas. The study established some limitations faced by farmers during the process of adopting TC banana technology adoption. These were as follows: lack of finance, high costs of inputs, the high cost of TC plantlets, poor information exchange, poor agricultural extension services, labour-intensive, decision-making at household, culture, and traditions, risk avoidance mechanism, and engagement in other practices to meet farmers' needs.

Sampled farmers suggested interventions to be put in place to overcome the constraints faced during TC banana adoption, and these were as follows: advancing credit facilities, formation of farmers' groups and associations supporting research and development, implementing advancements by extension workers, improving road network, implementing disease control measures and attending workshops and seminars,

5.3 Conclusions

By the evidence generated in this study, some conclusions and generalizations on the determinants of adoption of banana TC technology by farmers can be constructed. First, it can be deduced from the study that social factors significantly affect TC banana technology adoption. It can be generally accepted that farmers' social attributes significantly influence the adoption of banana TC technology by farmers. These attributes include gender roles and decision making at the household. Secondly, economic factors like land, finance, farm input and labour play a significant role in influencing the adoption of TC banana technology.

On the basis of the benefits stated by farmers who had adopted the TC banana technology, this study concludes that TC banana technology has more benefits than disadvantages despite its high costs of implementation. Key among the benefits is higher income generation than reliance on the tradition banana suckers. Other notable benefits include increased production enhanced by a harvestable bunch of bananas thus promoting food security between harvesting seasons of cereals.

Further, the study revealed some constraints which farmers noted as obstacles to the adoptionof TC bananas. Among those attributed by the respondents are: Lack of finance to buy inputs, poor infrastructure, decision making at household, high input requirements, poor agricultural extension services, lack of TC plantlets, labour intensity, other practices that meet farmer's needs, culture and traditions and risk avoidance mechanisms.

Respondents advocated some intervention measures which could aid in combating these constraints. These include the following: advancing credit facilities, the formation of farmer's groups and associations, supporting disease control programmes, improving road network as well as attending workshops and seminars.

This study has confirmed the important role TC banana technology plays in enhancing banana production to improve food security and income generation in the study area. Hence if properly adopted it will improve the livelihood of resdents of Nyamira County.

5.4 Recommendations of the Study

Based on the findings of this study, the following recommendations were made:

i. Promoting the formation of savings and credit cooperatives among banana farmers. This will help them market and provide credit to finance TC banana farming (purchase of farm inputs and labour) through partnering with relevant local financial institutions.

ii. Improving the flow of information and awareness creation among small-scale farmers. This should adopt group approach demonstrations like women groups to enable a larger number of farmers to be reached and access the information.

iii. Enhancing agricultural extension services on research development to farmers in rural areas. Extension workers to actively participate in disseminating farmers on good farming practices.

iv. The government to establish one nursery of TC bananas in each ward in Nyamira North sub county to make farmers access TC plantlets easily. Besides, it should come up with strategies of subsidizing the high cost of tissue-cultured banana plantlets to make them affordable for farmers to adopt.

v. Improving the road network in rural areas. Banana farming is usually done in rural areas; therefore, there is need for road upgrade to promote transport of bananas since they are perishable crops.

5.5 Suggestions for Further Research

The following suggestions for further research were made:

i. The role of creating awareness among farmers in participatory dissemination of TC banana technology adoption.

ii. A critical study on the impact of value addition on a banana and how it affects the adoption of TC banana technologies needs to be conducted.

iii. Social network analysis to identify all actors involved in TC banana programs in Kisii and its locations, to clearly reveal which actor can be used to disseminate TC information efficiently.

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APPENDICES

Appendix I: Introductory Letter

Dear Participant,

My name is Evans Motanya Nyang'au, currently taking a graduate degree at Kenyatta University. I am undertaking a research project, "***Evaluating The Determinants For The Adoption Of Tissue Culture Banana Technology By Small-Scale Farmers In Nyamira County, Kenya."*** As a small-scale banana farmer in Nyamira County, you have been chosen to participate in the study and your contribution will be highly appreciated. Once this review is complete, it will enable the ministry of agriculture and stakeholder to enhance banana farming yields. This information can also be used by the government agencies to make informed moves concerning agricultural technology and its adoption. Kindly respond to each and every question as honestly as possible since the results of the study depend on you. The information you give shall remain confidential; and anonymous.

Thank you for taking the time to assist me with the information you have.

Yours sincerely,

NYANG'AU M. EVANS

C50/CE/23759/2013 (Master of Arts)

Appendix II: Questionnaire for Farmers

Tick where applicable Date…….

A. General Information

1. Name of household/respondent: _____
2. Residence

   Village: _____

   Sub-Location: _____

   Location: _____

   Division: _____

   Sub-County:_____
3. Gender of respondents

   Male

   Female
4. Age of respondents

   _____
5. Marital Status;

   Married ☐

   Single ☐

   Widowed ☐

   Widower ☐

   Separated ☐

6. Main Occupation

   _____

   _____

   _____

7. Food crops cultivated?

   Maize ☐

   Beans ☐

   Bananas ☐

   Other (specify) _____

Section B: Land

8. Farm Size _____ acres
9. Land ownership:

   Family land ☐

   Free hold land ☐

   Bought ☐

   Inherited ☐

   Rented ☐

B. **Technology Dissemination**

10. Have you ever attended TC dissemination meeting organized by agricultural extension officers?

    Yes ☐

    No ☐

a. If yes, state the demo-site or the farm owner where you attended

_____

_____

b. Who notified you of the above meeting

_____

_____

11. Is the process of notification satisfactory to you?

Yes ☐

No ☐

12. Did you learn a new farm practice in banana production?

Yes

No

If yes, what did you learn? _____

Section C: Technology Adoption

13. What variety of bananas do you plant?

i. _____

ii. _____

iii. _____

14. After the exposure did you decide to use the technology?

Yes ☐

No ☐

15. According to you, does TC technology improve crop production?

Yes ☐

No ☐

16. How are farmers involved in TC technology adoption process?

_____

_____

_____

Section D: Socio-Economic

17. Indicate who make each of the following decisions.

Decision	Decision Maker			
	Husband	**Wife**	**Son**	**Daughter**
Farm to grow food/cash crops.				
Attend agricultural meetings				
Use of TC technology				
Provide farm inputs				
Market farm produce				

18. Tick on the constraint that prevents some farmers from using TC technology

Key: **SA - Strongly Agree, A – Agree, D – Disagree, SD - Strongly Disagree, N – Not sure**

Constraints	**SA**	**A**	**N**	**D**	**SD**
Lack of finance to buy inputs					
Culture and traditions					
Poor information exchange					
Other practices that meet farmer's needs					
Decision-making at household					
High inputs requirements					
Labour at the household					
Risk avoidance mechanism					
Lack of TC seedlings					
Poor agricultural extension services					

19. How can we encourage farmers to adopt TC technology?

i. _____

ii. _____

20. What are the Benefits of TC banana technology adoptions?

Benefit	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Increased yield					
More income generating					
Pest and Disease resistant					
Short Growth period					
Promotes food security					

Thank You for Your Participation

Appendix III: Interview Schedule

Agricultural extension officers **Date: ……**

Residence and workplace

Sub-County	Division	Location	Sub-Location	Village

Background information (N.B: Tick where applicable)

1. Gender _____
2. Highest education level attained_____
3. Professional area of specialization_____

Extension services

4. Indicate your attitude towards the scaled responses on the role of extensionists in the promotion of TC technology.

Key: **SA - Strongly Agree, A – Agree, D – Disagree, SD - Strongly Disagree, N – Not sure**

Role	SA	A	N	D	SD
Organize meetings and facilitate programs					
Provide TC plantlets to farmers					
Guide in the implementation of TC					
Motivate farmers to adopt TC					
Assist farmers in monitoring and evaluation					

5. Indicate how often you use the following extension approaches in your daily activities.

Approach	Frequently	Occasionally	Rarely	Never
Farm visit				
Farmer to farmer extension				
Informal contacts				
Demonstration plot				
Field training				
Audiovisual				
Exhibitions				

6. Indicate by ticking the constraints that prevent some farmers from using TC technology

Key: **SA - Strongly Agree, A – Agree, D – Disagree, SD - Strongly Disagree, N – Not sure**

Constraint	SA	A	N	D	SD
Lack of finance to buy inputs					
Lack of tissue plantlets					
Decision-making at the household level					
Poor information exchange					
High input requirements					
Risk avoidance mechanism					
Culture and traditions					

7. From you, observation, explain whether gender (i.e., men and women) consideration is done during the implementation of TC technology

Thank you for your participation

Appendix IV: Interview Schedule for KARI Officers

Sub-County	Division	Location	Sub-Location	Village

Background information (Tick where applicable)

1. Name
2. Sex
3. Highest education level achieved
4. Professional training
5. How long have you worked in the demonstration?

Information exchange

6. Indicate by ticking, the channel(s) used to give instructions

Channel	Frequency		
	Always	Sometimes	Never
Written instructions			
Verbal instructions			
Verbal through messages			

6. Of the channels indicated above, which one would you prefer?

_____

7. How often do you visit farmers' farms for technical advice?

_____

8. Do farmers visit your offices of professionaladvice besides the official administrations you organize for them?

_____

_____

_____

__

9. What are some of the challenges farmers face in implementing TC technology?

i. _____

ii. _____

iii. _____

iv. _____

v. _____

vi. _____

10. How can farmers be motivated to adopt TC technology?

i. _____

ii. _____

iii. _____

iv. _____

v. _____

11. What challenges do you encounter as you manage the demonstration site

i. _____

ii. _____

iii. _____

iv. _____

v. _____

12. Suggest some of the solutions to the problems you face.

i. _____

ii. _____

iii. _____

iv. _____

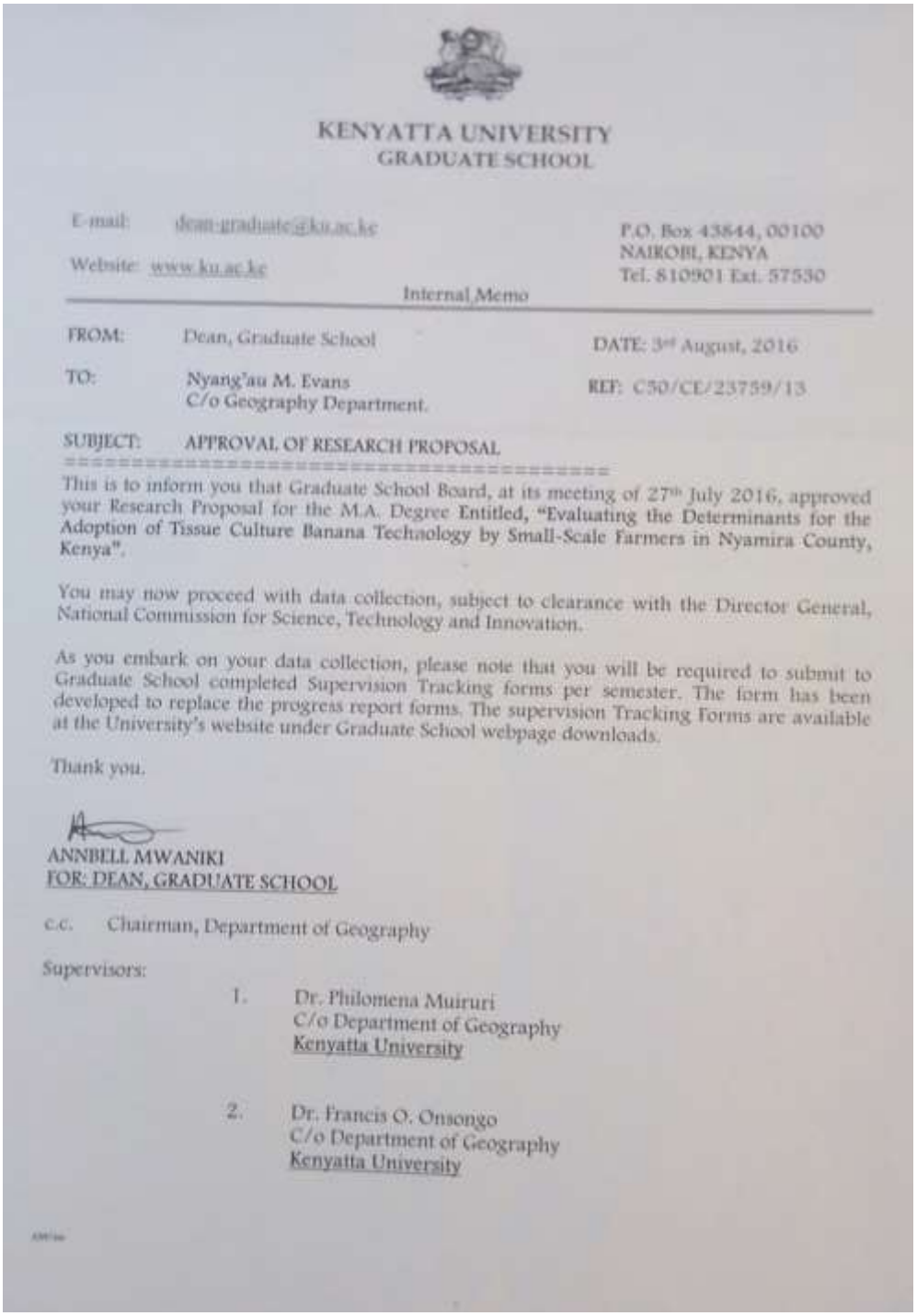
v. _____

Thank You for Your Participation

Appendix V: Observation Checklist

S/N	Aspect to be observed	Remarks
1.	Type of banana variety grown	
2.	Other crops are grown	
3.	Field practices i. Pruning ii. Staking iii. Weeding iv. Pest and disease	
4.	Environment protection	
5.	Type of farming practices	

Appendix VI: Graduate School Approval Letter



KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School

DATE: 3rd August, 2016

TO: Nyang'au M. Evans
C/o Geography Department.

REF: C50/CE/23759/13

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board, at its meeting of 27th July 2016, approved your Research Proposal for the M.A. Degree Entitled, "Evaluating the Determinants for the Adoption of Tissue Culture Banana Technology by Small-Scale Farmers in Nyamira County, Kenya".

You may now proceed with data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking forms per semester. The form has been developed to replace the progress report forms. The supervision Tracking Forms are available at the University's website under Graduate School webpage downloads.

Thank you.

ANNBELL MWANIKI
FOR: DEAN, GRADUATE SCHOOL

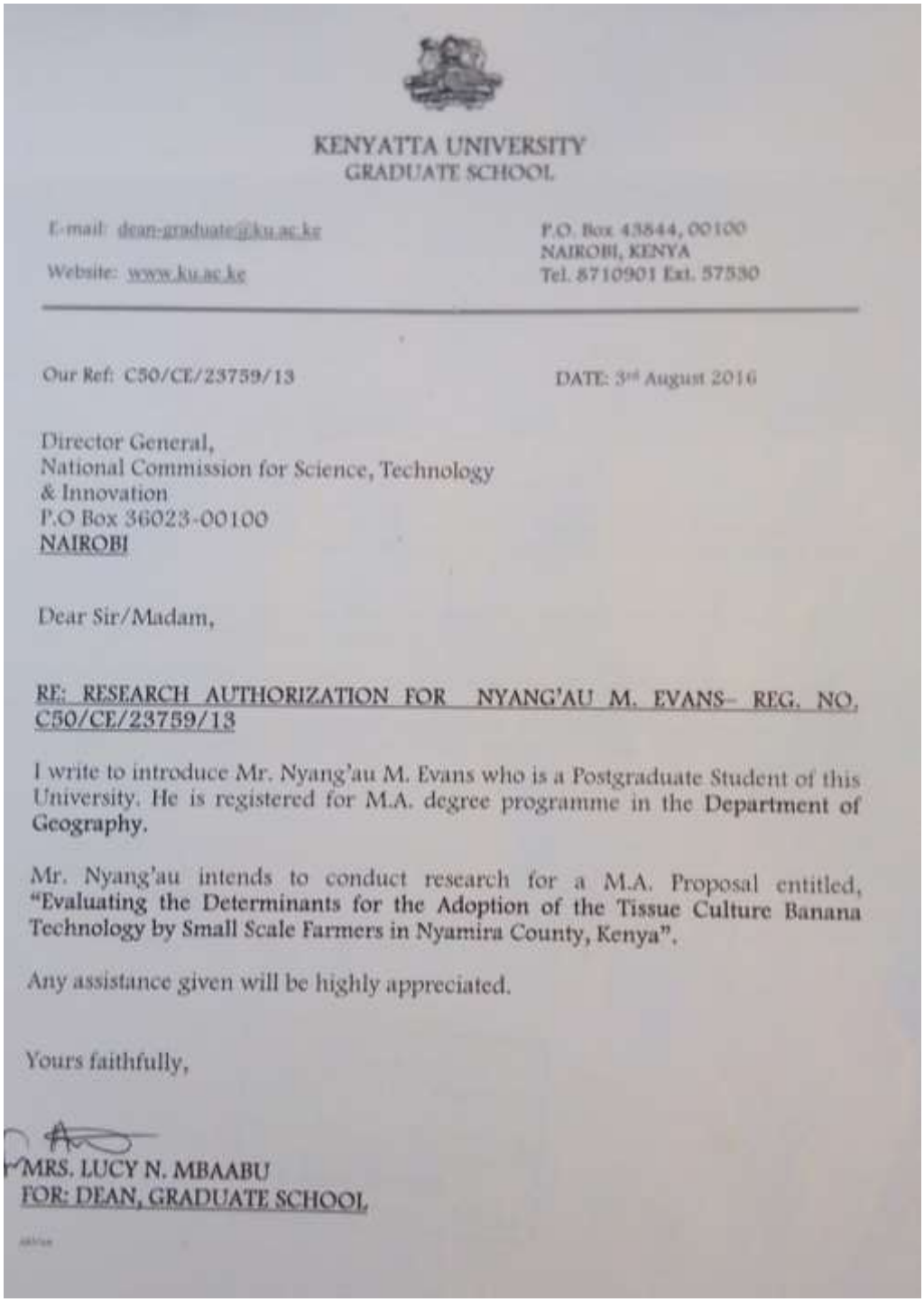
c.c. Chairman, Department of Geography

Supervisors:

1. Dr. Philomena Muiruri
C/o Department of Geography
Kenyatta University

2. Dr. Francis O. Onsongo
C/o Department of Geography
Kenyatta University

Appendix VII: Graduate School Authorization Letter



KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: C50/CE/23759/13

DATE: 3rd August 2016

Director General,
National Commission for Science, Technology
& Innovation
P.O Box 36023-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR NYANG'AU M. EVANS– REG. NO. C50/CE/23759/13

I write to introduce Mr. Nyang'au M. Evans who is a Postgraduate Student of this University. He is registered for M.A. degree programme in the **Department of Geography.**

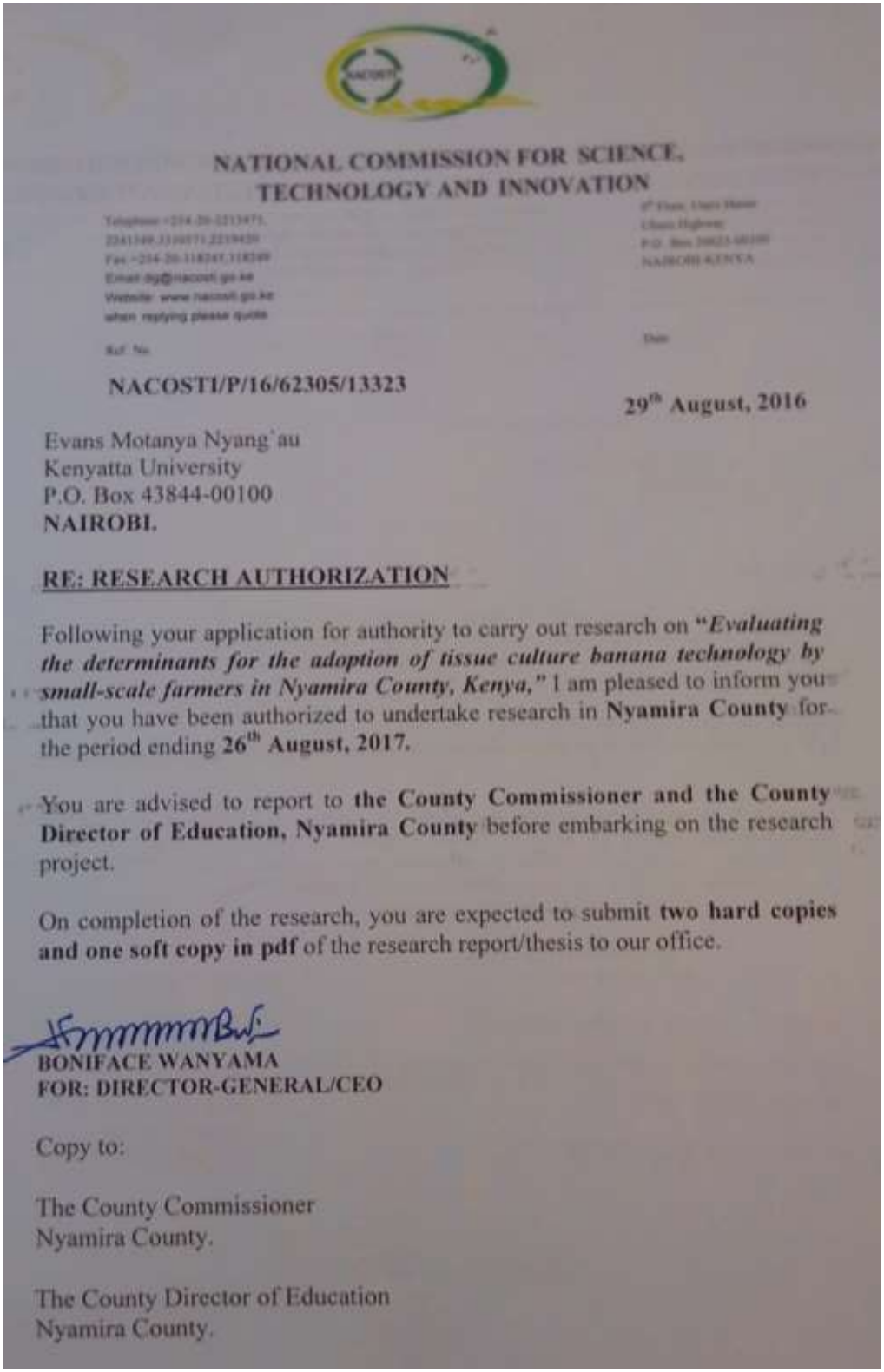
Mr. Nyang'au intends to conduct research for a M.A. Proposal entitled, **"Evaluating the Determinants for the Adoption of the Tissue Culture Banana Technology by Small Scale Farmers in Nyamira County, Kenya".**

Any assistance given will be highly appreciated.

Yours faithfully,

MRS. LUCY N. MBAABU
FOR: DEAN, GRADUATE SCHOOL

Appendix VIII: NACOSTI Authorization Letter



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone +254-20-2213471,
2241349,3310571,2219420
Fax +254-20-318245,318249
Email dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

Ref. No.

NACOSTI/P/16/62305/13323

Date

29th August, 2016

Evans Motanya Nyang`au
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Evaluating the determinants for the adoption of tissue culture banana technology by small-scale farmers in Nyamira County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Nyamira County** for the period ending **26th August, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Nyamira County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

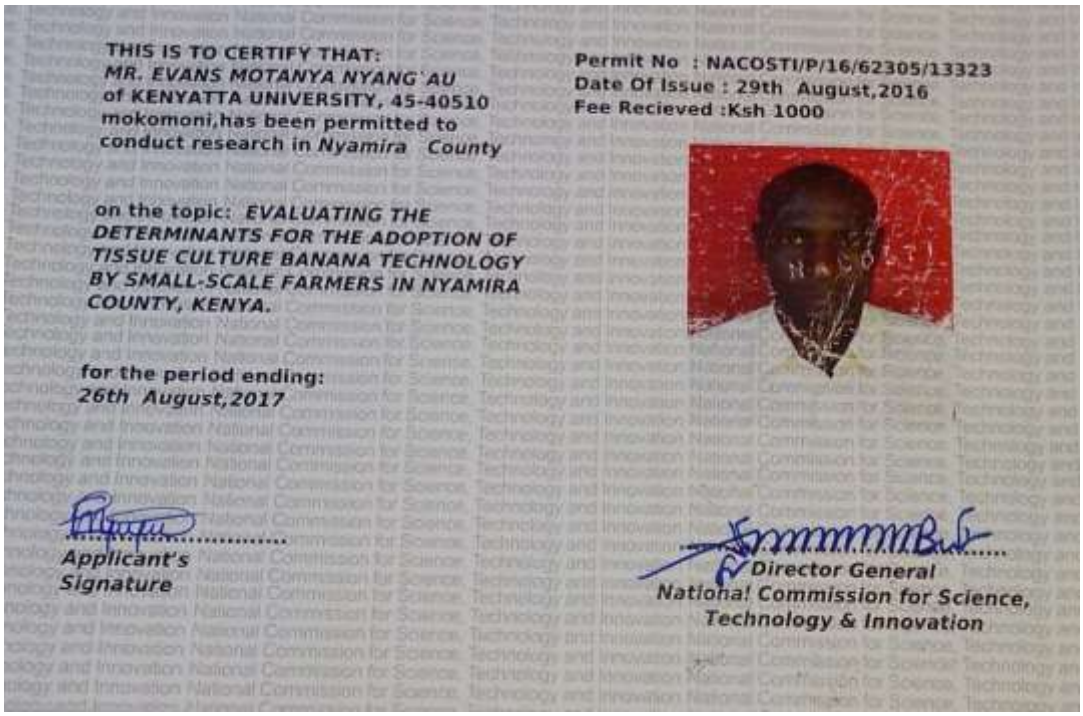
BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nyamira County.

The County Director of Education
Nyamira County.

Appendix IX: Research Permit



THIS IS TO CERTIFY THAT:
MR. EVANS MOTANYA NYANG`AU
of KENYATTA UNIVERSITY, 45-40510
mokomoni,has been permitted to
conduct research in Nyamira County

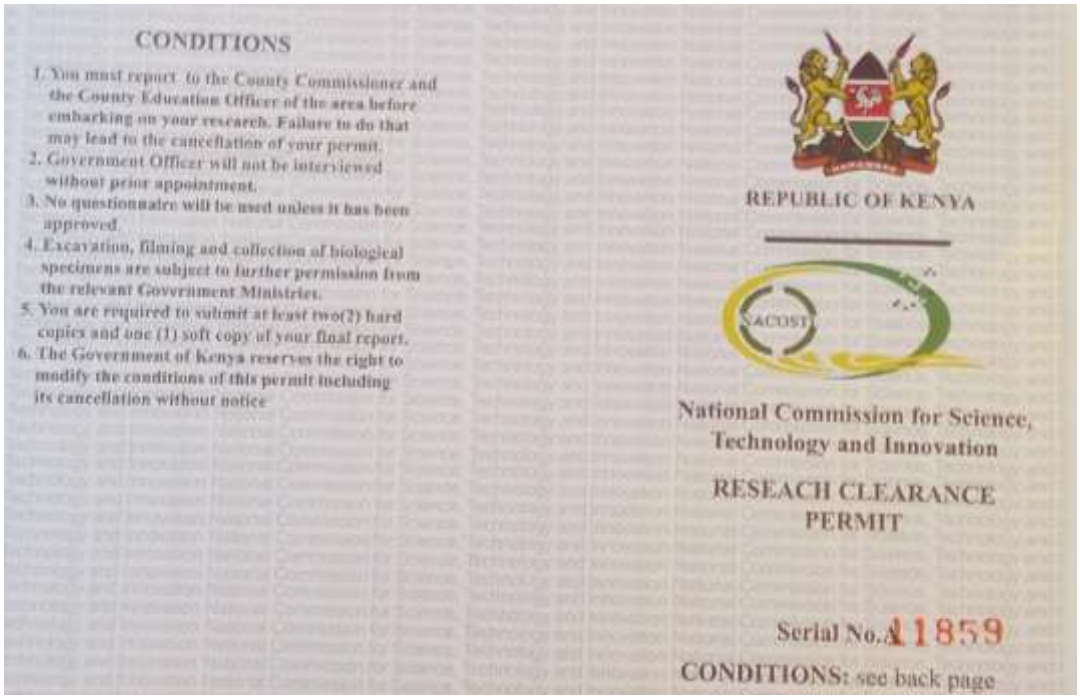
on the topic: EVALUATING THE DETERMINANTS FOR THE ADOPTION OF TISSUE CULTURE BANANA TECHNOLOGY BY SMALL-SCALE FARMERS IN NYAMIRA COUNTY, KENYA.

for the period ending:
26th August,2017

Applicant's Signature

Permit No : NACOSTI/P/16/62305/13323
Date Of Issue : 29th August,2016
Fee Recieved :Ksh 1000

Director General
National Commission for Science, Technology & Innovation



CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 11859

CONDITIONS: see back page

Appendix X: County Commissioner Authorization Letter

REPUBLIC OF KENYA

THE PRESIDENCY

Ministry of Interior and Coordination of National Government

Telephone: 020-2012491
Fax: 058-6144446
Email: conyamira@yahoo.com.
conyamira2012@gmail.com.

COUNTY COMMISSIONER
NYAMIRA COUNTY
P.O. BOX 2 - 40500
NYAMIRA

When replying please quote our

REF: NYRC/ED.2/VOL.I/178 **DATE: 21st September, 2016**

The Deputy County Commissioners
NYAMIRA COUNTY

RE: EVANS MOTANYA NYANG'AU - KENYATTA UNIVERSITY
RESEARCH AUTHORIZATION

Reference is made to letter Ref. No. NACOSTI/P/16/62305/13323 dated 29th August, 2016 from the Director General/CEO, National Commission for Science, Technology and Innovation, Nairobi authorizing ***Evans Motanya Nyang'au*** to carry out research on ***"Evaluating the determinants for the adoption of tissue culture banana technology by small-scale farmers*** **in Nyamira County"**

This is to inform you that the planned research will be conducted in Nyamira County, upto ***26th August, 2017.***

Kindly accord him the necessary assistance.

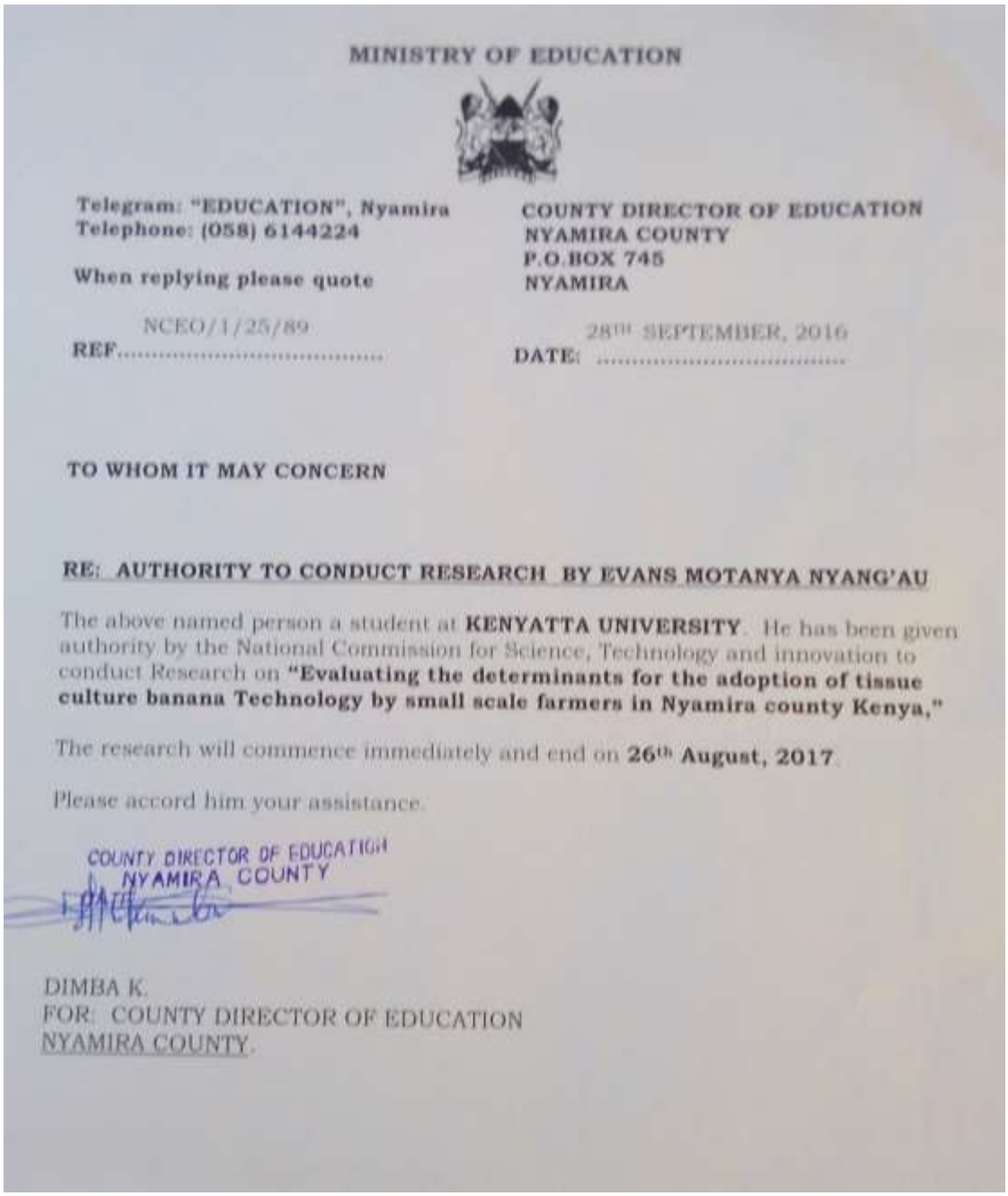
GRACE . NGINDA
FOR: COUNTY COMMISSIONER
NYAMIRA

Copy to:

National Commission for Science, Technology
& Innovation,
P.O. Box 30623
NAIROBI

County Director of Education
P.O Box 4
NYAMIRA

Appendix XI: County Director of Education Authorization Letter



MINISTRY OF EDUCATION

Telegram: "EDUCATION", Nyamira
Telephone: (058) 6144224

When replying please quote

COUNTY DIRECTOR OF EDUCATION
NYAMIRA COUNTY
P.O.BOX 745
NYAMIRA

REF: NCEO/1/25/89

DATE: 28TH SEPTEMBER, 2016

TO WHOM IT MAY CONCERN

RE: AUTHORITY TO CONDUCT RESEARCH BY EVANS MOTANYA NYANG'AU

The above named person a student at **KENYATTA UNIVERSITY**. He has been given authority by the National Commission for Science, Technology and innovation to conduct Research on **"Evaluating the determinants for the adoption of tissue culture banana Technology by small scale farmers in Nyamira county Kenya,"**

The research will commence immediately and end on **26th August, 2017**.

Please accord him your assistance.

COUNTY DIRECTOR OF EDUCATION
NYAMIRA COUNTY

DIMBA K.
FOR: COUNTY DIRECTOR OF EDUCATION
NYAMIRA COUNTY.