FACTORS INFLUENCING THE ADOPTION OF TISSUE CULTURE BANANA (*Musa paradisiaca*) TECHNOLOGY IN KISII COUNTY, KENYA

By

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DECLARATION

Candidate's Declaration

This thesis is entirely my work and hasn't been submitted to any other institution for award of degree or any other award.

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Signature Date

Supervisors' Declaration

We have approved the submission of this thesis for review as university supervisors.

1. Prof. Monicah Wanjiku Mucheru-Muna

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Department of Environmental Sciences and Education

DEDICATION

This work is in honor of my parents, especially my father, who sacrificed a lot to ensure that every one of his children received a quality education. I wish I could be half as patient and strict as my mother, who taught me the importance of both.

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My supervisors, Prof. Monicah Mucheru-Muna and Dr. Benson Kamau Mburu deserve my gratitude for their unwavering support during my studies by being constant, supportive, and constructive in their approach. I also wish to say thanks to the support I received from my household, whose tolerance and prayers granted me the zeal to finish my adventure. I would especially wish to thank the Bogusero community, KALRO, and MoA employees for helping to facilitate and support my data collection. Last but not least, I would like to give God praise for the priceless presence of life and all the advantages that led to the completion of this thesis.

ABSTRACT

To attain food security across the nation, the Kenyan government has made efforts over the years, although with varying degrees of success. Agriculture has been considerably intensifying to feed the expanding population. One technology utilized is the tissue culture banana technology. Kisii region is an important contributor to Kenya's food security due to its long history in food production for instance banana production. However, food production in the area has been on decline as a result of difficulties arising from social economic factors. Most research studies reveal low technology adoption rates, in Kisii County despite efforts to spread this technology to small-scale farmers. Therefore, the specific objectives of the study were; i) to examine the socioeconomic aspects affecting implementing tissue culture bananas in Kisii County. ii) to ascertain how tissue culture banana knowledge influences the use of tissue culture banana technology in Kisii County, and iii) to investigate the advantages brought about by Kisii County's small-scale farmers' adoption of tissue-cultured bananas. The study adopted a descriptive study approach. Simple random sampling was performed to select 200 respondents for the study. Data collection utilized survey forms, interview schedules, and checklists for observation A five-Likert scale analysis was utilized to collect farmers' degrees of awareness regarding Tissue Culture bananas and the benefits realized. Farm socio-economic characteristics were related to tissue culture banana adoption using comparative statistical procedures. For numeric characteristics, means between adoption categories were significant at $p<0.05$ using t-tests. Chi-square tests were conducted between adoption and categorical variables and significant relationships between the variables were declared at $p<0.05$. The study used a logistic regression model using maximum likelihood estimation to estimate the probability of tissue culture banana being adopted by farmers as influenced by several socio-economic characteristics. Mean comparison procedures were used to show the relationships between tissue culture banana knowledge items and tissue culture banana adoption. The means were also used to display the relationship between tissue culture banana benefits and adoption. Results showed that the size of household (p=0.05, Std=1.8), the availability of extension services (p=0.000, χ^2=79.1), ability to purchase land (0.006, χ^2=16.3), access to financing (p=0.007, χ^2=7.468), education level (p=0.015), ability to afford seedlings (p=0.000, χ^2=17.6), labour availability (p=0.005, χ^2=10.735) and availability of farm inputs (p=0.000, χ^2=35.9) had a profound effect on the uptake of tissue culture bananas. Responses from qualitative data were analyzed and presented in narrative form. Adoption of bananas from tissue culture was found to be significantly impacted by the farmers' low level of knowledge about the subject. Majority of farmers were aware of the advantages of tissue-cultured bananas, but were constrained by socioeconomic issues that prevented them from implementing the technology. Socio-economic factors should be taken into consideration in anticipation to help a variety of stakeholders' increase banana production through tissue culture adoption and improve food security.

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LIST OF ACRONYMS AND ABBREVIATIONS

APAARI	Asia-Pacific Association of Agricultural Research Institutions
BSV	Banana Streak Virus
FAO	Food and Agricultural Organization
GOK	Government of Kenya
HH	Household Head
IDRC	International Development Research Centre
ISAAA	International Service for Acquisition of Agri-biotech Applications
ISFM	Integrated Soil Fertility Management
KARI	Kenya Agricultural Research Institute
KARLO	Kenya Agricultural & Livestock Research Organization
KIRDI	Kenya Industrial Research and Development Institute
RF	Rockefeller Foundation
SNCDP	Southern Nyanza Community Development Project
SPSS	Statistical Package for the Social Sciences
TAM	Technology Adoption Model
TC	Tissue culture
UNEP	United Nations Environmental Program
USAID	US Agency for International Development

DEFINITION OF TERMS

Adopters: A person or organization utilizing modern technologies (FAO, 2017).

Adoption: The process through which people or organizations accept and utilize new technologies (FAOSTAT, 2018).

Banana: This is a tasty tropical fruit, primarily grown in Africa but also found in Asia and the Pacific, which lacks seeds (Nakasone et al., 2012).

Food security: This is a situation whereby everyone has constant access to enough wholesome food to satisfy dietary habit requirements and dietary preferences for a fit and energetic lifestyle existence on all levels—physically, economically, and socially (FAO, 2018).

Non-adopters: A person or organization that never begins utilizing modern technologies (FAO, 2017).

Tissue culture: This is the regulated aseptic multiplication of a plant part, either one cell or a collection of cells in a test tube (APAARI, 2019).

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CHAPTER ONE: INTRODUCTION

1.1: Background Information

Hunger is the biggest issue in the world, where it affects 98 million Africans out of the 840 million hungry people worldwide, or more than 20% of the issue (KARI, 2012). With many countries of Sub-Saharan Africa (SSA) having a large agricultural workforce; with agriculture providing the primary means of support for rural residents (Panel *et al*., 2011), over 10 million Kenyans, or about 25% of the population, still lack access to enough food in both quantity and quality hence depending primarily on food aid at any one period of the year (Sibhatu *et al.*, 2015). Loss of assistance and a rise in poverty rates are both intimately related to this food inaccessibility (Group, 2018). Unicef *et al.*, (2017) indicated that the national headcount rate for food insecurity suggested that 14.5 million people nationwide were living in food insecurity with higher incidences being in rural areas which was represented by 64.2% of individuals who are food insecure. Estimates from the Global Report on Food Crises similarly indicated that over a ten-year period, the number of persons experiencing food insecurity in Kenya increased dramatically, rising from 1.3 million in 2007 to 2.2 million in 2017 (Unicef *et al.*, 2017).

To deal with the concerns of hunger and poverty and keep up with the growing population in the world, Kenya and other Sub-Saharan African nations must adopt the proper agricultural interventions, according to the Sustainable Development Goals (Kentikelenis *et al*., 2016). This means that, barring the discovery of a solution, developing countries like Kenya with high rates of growth in the population won't be able to match their food demands in comparison to industrialized ones (Fischer & Qaim, 2012). It will be essential to boost existing production levels of food higher, proportionally to a growing population to supply them with an appropriate diet because many people in underdeveloped nations are undernourished (Joosten *et al*., 2015). Experts lament that widely used green revolution technologies no longer offer breakthroughs in yield potential or solutions to challenging insect, disease, and drought stress issues; as a result, the future production issue won't be addressed by agricultural technology in its current condition, necessitating the development of new strategies to increase food production (Karembu *et al*., 2010).

It's well acknowledge that the *Musaceae* family plant, the banana, provides more than 25% of the world's demands for carbs (Njue, 2015). In most developing nations, the banana comes in fourth place among food crops, behind rice, wheat, and maize; as a result, it is a major employer and a source of both on- and off-farm earnings in key industrial settings hence to guarantee food security its intensification must be stressed (Tumuhimbise & Talengera, 2018). Uptake of banana tissue culture technology as with other advanced technologies, offers the advantage of increasing access to food, income creation through produce sales, government revenue, and employment opportunities for women and young people (Wambugu *et al*., 2008). But what has to be done to advance more effectively in the future and how far have researchers actually come in terms of ensuring that small-scale farmers have the information, tools, and goods necessary to engage in tissue culture banana production (Woomer, 2012). Wahome *et al*. (2021) noted that given the limitations in knowledge, uptake, and exploitation of banana tissue culture technologies, research must be encouraged to try and close these gaps.

Lack of accurate and timely information access has been cited as a significant barrier to Kenya's rural agriculture's development (Adolwa *et al*., 2010), making it impossible to build tissue culture banana technologies, especially given how ignorant the end users and home characteristics are. Additionally, the type of information that smallholder farmers possess is not entirely documented (Obala, 2013). Researchers and extension personnel have been sharing information for a while, but adoption advancements have not yet been completely realized. It is important to investigate the unique expertise that farmers have in producing tissue culture bananas, as well as the social and economic aspects of households and the benefits of doing so. Thus, it is necessary to conduct this research to identify the social and economic variables that influence acceptance and use, evaluate the level of knowledge held by smallholder farmers, and identify the benefits of banana tissue culture cultivation.

1.2: Problem Statement and Justification

When growing bananas, conventional agricultural practices have several drawbacks. These shortcomings include a lesser yield as well as the emergence of diseases and pests. The quality of agricultural yields is another factor that affects productivity fluctuations from one year to the next. Because of this, there is a lack of crops, which is why the price is so high. This has enhanced the necessity to take into account different agricultural methods that could increase crop productivity, such as the tissue culture method (Khalid & da Silva, 2010). Despite a large increase in yields, a prior study on the banana tissue culture technique indicated a low adoption rate of the technology, particularly among small-scale farmers (Mbogoh *et al*., 2003). Despite any possible advantages of methods for banana tissue culture, including the quick creation of a large number of disease-free planting materials in the Embu, Kisii, and Nyamira counties, there is generally a low acceptance rate of this technology (Wahome *et al*., 2021).The low rate of adoption might potentially have an impact on up to 3 million Kenyans whose primary source of income is farming, threatening their access to food, employment prospects, and financial stability not only in Kisii County but also in areas that might grow bananas (World Bank, 2014).

Due to the coffee industry's demise in Kisii County as a result of falling coffee prices and falling tea prices, banana growth has become a significant income crop (Nguthi, 2007). Bananas in the County are now classified as a crop for both food and profit as a result of the change. The Kisii County Government is building a banana factory hence more farmers are predicted to switch to growing bananas or increase their output as a result of the new factory. However, home acceptance of tissue culture banana technology has been minimal, necessitating a research project to pinpoint the elements influencing this adoption. Therefore, this study analyzed the variables influencing farmers' adoption of the tissue culture banana technique in Kitutu Chache South Sub- County, Kisii County.

1.3: Research Questions

The research sought to answer the following questions.

i. How do the socioeconomic factors of farmers affect the use of tissue culture bananas in Kisii County?

ii. How do Kisii County's small-scale farmers' levels of knowledge of tissue culture bananas affect their decision to grow them?

iii. What advantages do small-scale banana producers in Kisii County gain from the use of tissue culture bananas?

1.4: Objectives

The research objectives were:

i. To examine the socioeconomic factors affecting acceptance of bananas grown through tissue culture technique in Kisii County.

ii. To determine how tissue culture banana knowledge influences the uptake of tissue culture banana technology in Kisii County.

iii. To investigate the advantages brought about by adoption of tissue-cultured bananas Kisii County's small-scale farmers.

1.5: Hypotheses

The following hypotheses served as a guide for the study:

Ha_1 Tissue culture adoption in Kisii County is greatly influenced by socioeconomic factors of the farmers.

Ha_2 Bananas growing in Kisii County using tissue culture is greatly influenced by the farmers' level of knowledge about tissue culture bananas.

1.6: Significance of the Study

The results will be tremendously beneficial to farmers and other development organizations. They will aid in their promotion of the tissue-cultured banana technique, which will serve as an intervention to address production issues. The outcomes of the study will be used as a rationale for educating the Kisii County authorities on the possible advantages of tissue-cultured bananas in lowering food insecurity there. Tissue-cultured bananas will increase banana production and provide a source of income, hence reducing poverty.

1.7: Conceptual Framework

Theoretical and practical strategies to encourage the adoption of innovative farming practices have been thoroughly researched in the agricultural industry (Kuehne *et al*., 2017). The adoption literature record makes an effort to categorize and arrange the factors that affect the spread of agricultural practices and the adoption of technology (Kuehne *et al*., 2017). Extrinsic variables, which can be categorized into three categories: qualities of the farmer, features of the outside world and the attributes of the innovation, have historically been emphasized in theories about decision-making processes (Meijer *et* *al*., 2015). Numerous empirical studies for the aquaculture industry (Amankwah *et al*., 2018) and a recent assessment by Kumar (2017) identified a number of factors influencing the adoption of agricultural technologies. Kumar (2017) recognized source of knowledge, technological characteristics, economic considerations, agricultural characteristics, and socio-demographic and institutional aspects.

Figure 1.1 demonstrates a framework demonstrating the relationships and interactions between the extrinsic variables (a and b) and the intrinsic variables (d, e, f), as well as the impact of the intervening variable (c) on the decision-making process for Tissue Culture Banana technologies and the potential effects of technology adoption on livelihood (Meijer *et al*., 2015). Experts from a variety of fields and backgrounds have focused on the internal decision-making process that goes beyond the simple traits of farmers, environments, and technologies by integrating psychological and motivational variables in technological uptake (McDonald *et al*., 2016). For instance, Davis (1989) presented the Technology Adoption Model (TAM) as a causal model, according to which consumer acceptance and usage of technologies are influenced by two important beliefs or components of an attitude i.e., the technology's perceived usefulness (PU) and perceived usability (PEOU). In contrast to perceived ease of use, which indicates the effort needed to acquire and use the technology, perceived utility of a technology represents the advantages that a person thinks technology can offer to increasing their output at work (McDonald *et al*., 2016). McDonald *et al*. (2016) showed that an agricultural organization will likely be more profitable and so develop competitive advantage if it adds more value to the world. As a result, it's crucial to make sure that these factors are given consideration when culturing of tissue banana is used in a community. The farmer must be capable to organize and bring together all the socioeconomic factors, as well as possess knowledge about tissue culture bananas, to decide whether to embrace or reject the method. When all of these elements are taken into account, farmers are more able to utilize the technology due to the fact that a farmer is influenced by all of these factors to form either positive or unfavorable beliefs and attitudes about tissue-cultured bananas, and as a result, they either utilize or don't use the method to grow bananas.

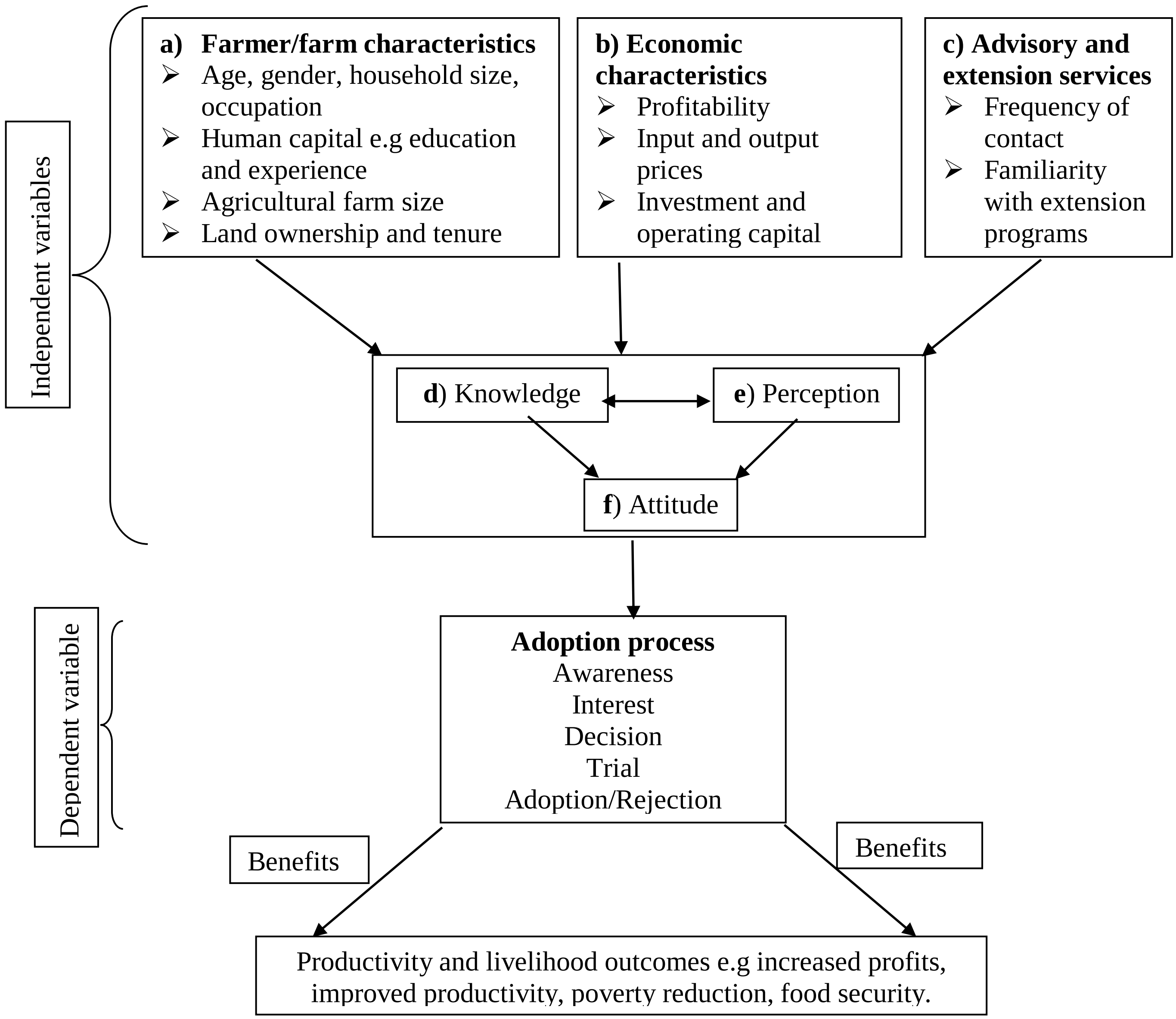

Figure 1.1 Conceptual framework (Source; An adaptation of Obiero *et al*. (2019))

CHAPTER TWO: LITERATURE REVIEW

2.1: Overview

Around the world, more than four million hectares of land are used to grow bananas, which produce more than 70 million tons of fruit annually (Pappu *et al*., 2015). Banana ranks behind sweet potato and cassava as the third-most significant starchy staple food (FAO, 2018). Bananas are mostly farmed and handled by smallholder farmers in Kenya, most of whom are peasant women (Paul *et al*., 2018) and contributes to around 32% of the total fruits export's foreign income (Directorate, 2016). Western, Central, and portions of Eastern areas were where most bananas were grown (Thuo, 2018). Due to their favorable agro-ecological conditions, which considerably encourage the growth of banana crops, these places have a strong potential for banana production. With an annual per capita consumption of 220-460 kg, bananas are primarily consumed domestically and account for more than 25% of all calories consumed (FAOSTAT, 2018).

Tissue culture of bananas is an essentially recommended agricultural technologies, although its adoption is only less than 7% in Kenya and even lower in Uganda and Burundi (Warinda *et al*., 2020). Kenya has been facing low banana output due to poor agronomic methods, and limited access to clean and economical planting supplies, despite the crop's importance and the existence of ideal producing locations (Wahome *et al.*, 2021). According to Wahome *et al*. (2021), the use of excellent planting materials, proper application of fertilizers, mulch, and manure, as well as labour, are the two most significant elements influencing banana productivity. A recent impact study for Kenya demonstrated beneficial yield impacts of adopting tissue culture bananas but also emphasized the significance of effective plantation management and expansion (Murongo *et al.*, 2022). Wahome *et al*. (2021), observed that there was potential to increase banana production in the research counties; however, the lack of knowledge among the populace and availability to necessary inputs in the three study areas was a challenge. To maximize their advantages, tissue culture banana plantlets need to be handled and managed properly hence the Kenyan farmers have an additional adoption difficulty as a result of this additional requirement and the comparatively high cost of tissue culture banana plantlets (US$ 1.20 to 2.00) (Wahome *et al*., 2021). To help farmers attain steady output levels, social economic factors, additional suggested practices, such as weeding, irrigation, desuckering, deleafing, and debudding, should be given enough priority (Warinda *et al*., 2020).

2.2: The development of banana farming

The first domestication of bananas took place in South East Asia, which is regarded as the key hub of the crop's diversification (Kasyoka *et al*., 2011). Also, to note, Southeast Asia is where edible *Musa* species first appeared, and then migrated westward along the main trade routes that carried other fruits (Perrier *et al*., 2011). This region shares borders with the countries of East Samoa and West India, Fiji and other islands in the South Pacific (FAOSTAT, 2018). Bananas left East Asia and spread throughout the world as a result of global human migration (Perrier *et al*., 2011). The greatest variety of genetic variability in plantains were found in the lowland regions of West Africa but as opposed to that, in the East of Africa, bananas have significantly changed into a highland bananas' secondary genetic diversity zone in the region (Perrier *et al*., 2011). The crop's economic significance has grown recently, and its commercialization is linked to demand brought on by expanding urbanization, which can give food security and a means of subsistence because It is suitable for use as a staple diet at home and then sold for money while shopping (Fischer & Qaim, 2012).

In 2017, more than 150 countries planted banana trees, yielding 113.91 million tons of global production (FAO, 2017). India was found to be the top banana producer in the world, providing around one-quarter of the global production, or 26.7% with a yearly production exceeding 30.47 million tons as per the report published by APAARI, (2019). Shahbandeh (2021) estimated that by 2020, banana production in Africa reached 21.48 million metric tons. In 2011, it was found that Uganda produced most bananas in Africa, accounting for 9.8 metric tons, or 7% of global production (Kasyoka *et al*., 2011). FAO (2018) however, reported that Cameroon was in the lead with an overall of 5.1 million tons. Adoption rates of banana tissue culture technology were found to be substantially lower in countries like Burundi and Uganda, among others; and banana tissue culture was projected to make up less than 7% by the year 2004 (Wambugu, 2004).

To boost banana productivity, the Ministry of Agriculture (MoA) and KARI introduced tissue-cultured bananas to assist in giving small-scale farmers hygienic planting materials (KARI, 2006). The value chain participants' technical proficiency was to be specifically developed to achieve this (KARI, 2006). It was thought that the development of the tissue culture method for quick multiplication in 1997 of wholesome planting supplies to Kenya could assist turn around the crop's decreasing trends (Kathenge, 2009). The International Development Research Center (IDRC), the Rockefeller Foundation (RF) (IDRC), and the Kenya Agricultural and Livestock Research Organization (KALRO) collaborated on an initiative to produce and provide smallholder farmers with clean banana planting material throughout the nation (Nguthi, 2007). Because of the constructive modifications in the sector, many small-scale farmers started growing bananas, but in the middle, the production was scant, inconsistently produced, and of varying quality (Senanayake & Rathnayaka, 2015). Years later, both small- and medium-sized farmers who did sell their banana products to nearby metropolitan markets realized that bananas had grown to be a considerable economic crop (Nguthi, 2008).

According to FAO (2001) clean planting was used as part of activities to encourage and simultaneously promote the replanting and rehabilitation of bananas. However, Kenyan farmers had not yet utilized tissue culture banana technology despite its potential to result in large harvests by the year 2011 (Kabunga, 2011). According to a study by Njuguna & Wambugu (2014), less than 10% of Kenyan banana growers used tissue culture to grow their crops. Even though majority of distribution operations in Kenya started in the Central and Eastern regions, there had been marginal adoption rates of up to 15% recorded there by 2012 (Kabunga *et al*., 2012). Just 27.8% of the Embu County farmers who were the subject of a study by Muthee *et al*. (2019) were using the technology for production that is advised, showing a generally low adoption rate. Many regions of Kenya, particularly those like Upper Eastern Kenya, Central Kenya, the Rift Valley, and portions of Nyanza, particularly the Kisii area, were exceptional in producing branded bananas for domestic and export industry (Tinzaara *et al*., 2018). In Meru County, more farmers opted for traditional bananas over tissue-cultivated ones for several reasons, based on a study by Kirimi *et al*. (2023).

The production of bananas in Kenya was found to be extremely subpar, averaging just 4.5–10 tons/ha, as opposed to universal annual standards of 40–50 tons/ha (Njue, 2015). In this instance, smallholder farmers, primarily peasant women, were in charge of growing and managing bananas (Kabunga *et al*., 2012). For instance, in Kenya, it contributed to around thirty two percent of the overall fruits exported foreign income by 2016 (Directorate, 2016). Majority of the Western, Central, and Eastern regions of Kenya were the areas where bananas were produced by 2014 (Wasala *et al*., 2014). This was attributed to their favorable agro-ecological conditions, which greatly encourage the growth of the banana crop, these regions possess a lot of promise for producing bananas.

Bananas totaling 1.7 million metric tons were produced in Kenya as of 2019, up from 1.4 million metric tons in 2018 (Faria, 2020). Wahome *et al*. (2021) reported that technique for banana tissue culture understanding was generally limited, with 60% of Kisii respondents reporting ignorance of the practice. Only 6.7% of Kisii County respondents planted tissue-culture bananas (Wahome *et al*., 2021). With a typical farmer output rate of 17 tons/ha, compared to the average for the country of 12 tons/ha, Kisii was once one of Kenya's top banana-producing districts (Kwach, 2014). However, Kisii County was ranked sixth nationally and generated 6% of all the bananas farmed in Kenya, according to Agwara (2017). According to Wahome *et al*. (2021), the two regions of Nyamira and Kisii were among the top producers of bananas in western Kenya. Historical evidence of Kenya and other nations shows that farmers may choose a single component of a technological package while rejecting or embracing a different component later on, dependent on their perceptions of profitability and risk (Mugo, 2013). The yield levels that could be obtained would change as a result of such specific adjustments to the package. However, due to post-harvest losses, small-scale banana growers who rely on the selling of fresh bananas to support their families have only made modest earnings (Obaga & Mwaura, 2018).

2.3: Physical Challenges Facing Banana Production

One of the major factors impacting banana production globally is climate change (Brascamp *et al*., 2018). Temperature and rainfall totals annually have negative effects on the rise in agricultural production i.e both the long term and near term (Adinew &

Gebresilasie, 2019). Long-term drought along with high temperatures and limited light availability reduces photosynthetic rates and leaf emergence (Turner, 1997). Thornes, (2002) noted that there is a large yield loss if temperatures rise by 2°C, which may be brought on by an increase in the risk of pests and illnesses. Even in places with moderate to low rainfall, water stress results in yield losses due to a decrease in bunch weight (Raderschall *et al*., 2021). In addition, Panigrahi *et al*. (2021) found that banana production uses irrigation as one of the simplest strategies to improve water stress management during dry years.

Opeyemi *et al*. (2016) indicated that strong winds have the propensity to upset the banana stool, resulting in decreased total banana yield and an increase in pest infestations. Insufficient soil moisture retention and poor/inefficient nitrogen cycling are two important obstacles to increasing banana output (van Asten *et al*., 2011). In East Africa, new diseases including Banana *Xanthomonas* Wilt (BXW) had been noted (Karembu *et al*., 2010). The soil-borne fungus *Fusarium oxysporum* F. sp. cubense (Foc), which causes the Panama disease (banana *Fusarium* wilt), was specifically responsible for the fall in banana production in Kisii and other regions (Thuo, 2018). Tissue culture had not been able to cure the viral problem, and until effective virus-eradication techniques have been found, some germplasm will only be allowed to move internationally (FAO, 2001). The difficulty with banana streak virus (BSV) is that traditional methods like heat treatment or apical tip culture cannot get rid of it (FAO, 2001). Despite these well-known difficulties, effective measures, such as providing tidy planting supplies by use of tissue culture and improving crop management ability, have greatly reduced the impact of pests and diseases even though they are not commonly used (Wambugu *et al*., 2008).

2.4: Socioeconomic Aspects Affecting Acceptance of Bananas Grown by Tissue Culture

In some cases, adopting enhanced agricultural advances may be a simple procedure before the technologies may be widely used. (Vernooy *et al*., 2015) argued that putting into practice agricultural technologies needed field testing, adaptation, adjustment, and correction. Even if innovations are extensively used, Njeri (2012) noted that they may not always have the desired results or may occasionally have unforeseen repercussions hence in this sense, it is crucial to recognize that the acceptance of agricultural technologies is a challenging, multiple-stage process. According to Mapila *et al*. (2011), studies on acceptance of modern technology by farmers end to focus on the decision to adopt additionally to the timing (early or late), in particular, in terms of the perspectives of the decision-makers, without flossing the innate qualities, with laggards at one end and innovators at the other. According Mapila *et al*. (2011), farmers have numerous goals, including appropriate financial income, food security, social security, and a stable source of resources.

Access to agricultural advising and extension services is essential for increasing the uptake of agricultural innovations and practices that are essential to agricultural productivity (Chowdhury *et al*., 2014). According to the innovation-diffusion theory, farmers' interactions by means of extension agents are anticipated to have a favorable impact on adoption (Darr *et al*., 2014) as these interactions subject farmers to the availability of accurate information anticipated to encourage uptake. According to Onyeneke *et al*. (2018), services for extensions are crucial sources of knowledge for adopting advised technologies in agriculture. The amount of adoption of the suggested agricultural technologies is predicted to positively correlate with contact with agricultural extension workers as the availability of information affects adoption (Kassem *et al*., 2019). According to Sapkota *et al*. (2018), farmers who receive more farm-related information are more prone to implementing new technologies or methods.

Kanyamuka (2017) found that smallholder farmers adoption was more prevalent when they had interacted with extension agents. According to Wahome *et al*. (2021), the ineffective management of banana production in high-potential locations is to blame for the low tissue culture adoption rate in Nyamira and Kisii in that the three regions' low productivity was believed to be a result of the restricted availability of agricultural services, that is dialogue with extension agents whereby none of the respondents had any interactions with extension agents (Wahome *et al*., 2021). The findings of Kathuri (2022) also indicated more extension interactions between farmers and extension agents improved the likelihood that farmers would adopt the recommended banana production technologies at low and medium levels by 5.64% and 1.67%, respectively. Adeyeye *et al*.

(2019) noted similar outcomes of the beneficial effects of extension engagement with farmers producing cowpea cultivars. Lim *et al*. (2017) examined the suitability of several techniques for extensions in Nigeria and noted that individual farm visits and field demonstrations are the most successful extension approaches. Field demonstrations and private farm visits were found to be the most effective extension strategies in a study on the suitability of several techniques for extensions in Nigeria (Falola *et al*., 2022).

According to Fischer & Qaim (2012), education is an input employed in the production process. Wahome *et al*. (2021) found that farmers' educational attainment has a big impact on how well-informed they are about agricultural trends and how they make decisions. Farmers are expected to rate the technique highly if they have heard positive things about bananas grown in tissue culture (Nyang *et al*., 2010). According to Wahome *et al*. (2021), agriculturalists with formal education are thought to be able to receive, process, and act upon fresh knowledge substantially more quickly compared to people with no formal education. Education helped people adopt a psychologically favorable emotional state that was conducive to accepting new technology in an effective and efficient way having an impact on both higher agricultural productivity levels and technology adoption in a prior study by Caswell *et al*. (2001).

According to the study results of Nyang'au (2019), 37% and 32% of those farmers who had chosen tissue culture had received a high degree of formal instruction whereby key informant interviews supported the finding that adoption of tissue culture banana typically needed some degree of instruction for the technology to be adopted effectively and efficiently. Nyang'au (2019) maintained that formal education had an impact on the adoption of technology for improving bananas because it improves farmers' logical capacity to acquire, process, and comprehend information that was thought to be crucial for the adoption of such technologies. Mucheru-Muna *et al*. (2021) observed that farmers with higher levels of education had moderate to high knowledge of fertilizer usage, whereas training was positively correlated with a farmer's having moderate to high knowledge of manure use. As a result, compared to farmers with less education, educated farmers were more likely to understand information, seek out, and use more specialized or explicit knowledge (Mucheru-Muna *et al*., 2021).

Smallholder farmers' prior farming experience has a significant impact on their decision to embrace a particular technology at an early stage while they are still evaluating its potential advantages (Ainembabazi & Mugisha, 2014). An additional year of farming experience reduced the possibility of a farmer adopting the suggested banana production technology at a low level by 78.6%, favouring the preferred category (high adoption level) (Kathuri, 2022). In Uganda, it was noted that smallholder farmers' prior farming experience had a significant impact on their decision to embrace a particular technology at an early stage while they were still evaluating its potential advantages (Ainembabazi & Mugisha, 2014). According to Nyang'au (2019), 11% of farmers had been at it for fewer than three years, while 19% had been at it for more than twenty hence concluding that tissue culture adoption was influenced by prior experience in banana farming and that the farmers were not eager to switch to tissue culture hence demonstrating that producers who had been involved in banana growing for a long time had greater reliance on the suggested technologies. Smallholder farmers were more likely to embrace certain recommended agricultural technologies when they had prior farming experience (Mamuye, 2016). The possibility of tissue culture banana adoption in Western Kenya's four counties was found to be strongly influenced by the banana seedlings grown from tissue culture availability (Masinde *et al*., 2013). Also to note, the poor adoption rate of the technique in large parts could be due to the fact that only 11.1% of those surveyed in the Embu, Kisii, and Nyamira counties reported having an approved source for the tissue-cultured banana seedlings (Wahome *et al*., 2021).

To successfully implement various agricultural practices or advances, farmers must be financially capable (Vera *et al*., 2017). As a result, financial empowerment is essential for agricultural innovations to become widely used as some experts believe that adopting and disseminating agricultural technology is the greatest way for emerging nations to catch up with developed countries (Foster *et al*., 2010). When the cost of planting material for tissue cultures drops, adoption increases, and vice versa (Chandler, 1995). However, because of poverty and an insufficient purchasing power, households have very limited options for some technology, like bananas grown through tissue culture (Wanyama *et al*., 2016). Social impact and farmers' inventiveness were among the most important aspects, according to a study evaluating the determinants of Uganda's adoption of tissue culture planting material (Murongo *et al*., 2018). To Kathuri (2022), a one-shilling increase in farmers' access to financing reduced the likelihood that they would choose the recommended banana production methods at a medium level by 6.74%. Additionally, among small-scale farmers, a rise in the quantity of finance obtained enhanced the likelihood that farmers would adopt the recommended technology (Bajracharya *et al*., 2016). When it came to explaining changes in coffee yield, loan availability had a positive and considerable elasticity; similar results on the impact of loans on farm productivity were revealed by Musaba & Banda (2020). According to Nyang'au (2019), only 14% of respondents had access to financial facilities, compared to 86% of the banana producers in his findings: some farmers were unable to use financial facilities.

According to Kaaria *et al*. (2012), age plays a role in adoption decisions whereby it can result in both favorable and unfavorable outcomes (Woomer, 2012). As explained by Martey *et al*. (2014), because younger people are more energetic than older people, they are more likely to have more labour. Compared to older farmers who are acclimated to their agricultural operations, younger farmers have more time to experiment with new tactics (Akinola *et al*., 2010). In a study to identify the factors that affect the uptake of agricultural technology, Chuchird *et al*. (2017) found that age harmed the adoption of several technologies, including the irrigation used in farming. Nyang'au's (2019) study results indicated that 45% of those surveyed (aged between 36 and 45) had used culturing of tissue banana engineering whereas 2% farmers older than 56 years had adopted tissue culture technology. According to Kassie *et al*. (2009), economic motivation drives behavior to tissue culture uptake and the study also emphasized the role of age in farmers' reluctance to adopt new technologies after the age of 36 years. However, a study conducted by Muyanga (2009) found that although tissue culture improves farmers' livelihoods, age does not significantly influence their adoption of it.

Since membership in a group affects access to public spaces, especially in rural areas, it contributes to the development of farmers' social capital (Aryal & Holden, 2013). Being a member of agricultural organizations is essential to their members' education (Ojoko *et al*., 2017) as farmers can discuss their difficulties with their peers in agricultural associations or groups, where they can receive advice on how to deal with issues and therefore farmers who belong to organizations with a focus on agriculture may have improved access to resources and information (Ojoko *et al*., 2017). According to a study by Kathuri (2022), farmers' group membership had a favorable and significant impact on their uptake of the suggested banana-producing technologies as the results showed that group affiliation reduced by 6.54% the likelihood that a farmer would be in the favoured category if they adopted the suggested banana production practices at a low level. The results concurred with those of (Radhika *et al*., 2018) that showed that group participation influenced small-scale farmers' adoption of recommended agricultural technologies favorably.

According to Kamau *et al*. (2016), labour has the biggest and most noticeable effect on yields as farming activities including; weeding, fertilizer application, disease management, and harvesting are made easier by the availability of labour. According to Kathuri (2022), a one-man-day increase in labour availability reduces a banana farmer's likelihood of adopting the suggested technology for medium-level banana output by 6.72% supporting the selected category. These results support Dessale & others (2017) hypothesis that uptake of small-scale farmers of suggested agricultural technologies is greatly influenced by the occurrence of labour. Given the size of production, a rise in labour supply combined with a stable labour demand would result in lower wage rates and higher agricultural output per land unit (Kamau *et al*., 2016). Given the intensity of farm operations, the availability of labour would be essential for the production of bananas (Kamau *et al*., 2016). However, according to Mburu *et al*. (2014), there is a negative correlation between wheat productivity and family labour.

According to Wahome *et al*. (2021) men made up the majority of the responders. Women are entitled to use the land, and they perform majority of the domestic and agricultural work (Mugi-Ngenga *et al*., 2016). According to documented study conducted in Africa, women's access to vital resources (land, money, and labour) frequently hinders their capacity to organize labour (Nguthi, 2007). However, women perform better in labour-intensive practices, probably because of their higher social capacity to mobilize family or other reciprocal labour (Kanyamuka, 2017). Although this is a widely held belief, rural financial initiatives have typically been designed, built, and put into use with the intended user being the male leader of the home (Fletschner & Kenney, 2014). Therefore, it had been documented that the attitudes and behaviors of the transient community were dominated by male-headed households in that the males have an advantage in that their mobility which enables them to attend multiple training sessions and meetings hence families headed by men thus have greater access to information, which affects how they farm (Fletschner & Kenney, 2014).

Only 11.1% of the respondents from the three counties reported having a source for the seeds being a licensed one hence suggesting that a shortage of certified banana seedlings from tissue culture sources was a significant factor in the low adoption rate of this technology according to Wahome *et al.* (2021). According to Wanyama *et al*. (2016), the first and second barriers' investigation revealed accessibility of tissue culture banana plantlets to farmers was predicted to have a beneficial impact on the likelihood and intensity of tissue culture banana adoption. One percentage point increase in the availability of tissue culture banana would increase the adoption of tissue culture banana by about 70.5% (Wanyama *et al*., 2016). Kirimi *et al*. (2023) findings revealed that every banana planter surveyed was a small-scale farmer, which can impede crop expansion and, as a result, produce low farm revenues. Mwendia (2019) also conducted a study on the factors influencing households in Meru County, Kenya to diversify into banana farming and found out that majority of the respondents had extremely small parcels of land, which prevented diversification into large-scale banana cultivation in the study region.

According to Loevinsohn *et al*. (2013), new crop types and weed and pest control, irrigation, water management, soil fertility management, and management strategies are some of the most frequently created and promoted crop technologies. According to Challa & Tilahun (2013), new technology usually results in higher output and lower the average production cost, improving the connection between input and output, leading to significant increases in farm income. According to Nyang'au (2019) study findings, farmers with 4-5 acres of land had the highest adoption rate of tissue culture banana (34%) than those with over 5 acres (27%) as most of the farmers divided their land into tiny plots where they grew various kinds of crops and as a result, farmers of bananas with insufficient farmland were unable to use this technology. Regardless of the farmer's marital status, Nguthi (2007) came to the conclusion that the decision to adopt tissue culture bananas was influenced by money and the stability of the land's tenure. Also, the price of transportation and the distance to the market affect customers' decisions to adopt new technologies (Mbogoh *et al*., 2003). Nyang'au (2019) findings showed that 46% of married farmers and 7% of separated farmers both adopted tissue culture technology, demonstrating that marital status strongly influenced use of banana tissue culture technology.

2.5: How Tissue Culture Banana Knowledge Influences the Use of Tissue Culture Banana Technology

According to Wanyama *et al*. (2016), traditional methods for sustaining banana plot production included manure and mulch noting that farmers who used manure would probably advance to banana tissue culture techniques since manure was found to be less expensive than inorganic fertilizers. The growers were also aware that using manure was a necessary component of the tissue culture banana technology's agronomic package in order to reap its full benefits hence applied it in banana orchards at least half of a 20-kg tin per stool (Wanyama *et al.,* 2016). Application rates of 400 to 600 kg/ha/year of nitrogen, 200 to 300 kg per ha/year of phosphorus (P_2O_5), 850 to 1100 kg/ha per year of potassium, and 2 ton per ha/year of lime or dolomite were suggested for tropical bananas (Muthee *et al*., 2019). A study by Joshi *et al*. (2020) showed that only 35.9% of the responders fertilized their banana crop with the right amount of fertilizer as a majority of the farmers used organic manure to prepare the soil before applying synthetic fertilizers such as DAP, potash, and urea after the plant had established itself, one month after planting. Only 32.5% to 50% of Indian farmers applied the necessary amount of fertilizer to their banana crops; only 28% of respondents practiced crop rotation, and the majority of farmers either planted another species of bananas in the field or abandoned the land they had leased (Hassan, 2016).

Tiwari *et al*. (2006) noted that just 12.5% of Chitwan's banana farmers rotated their crops, and only 7.8% of those farmers had put cover crops or intercropped between the banana inter-rows. Hassan (2016) noted that in India's early stages, only 2.5–5% of farmers intercropped bananas. In addition to fertility management, farmers should place enough emphasis on other suggested measures including weeding, irrigation, de-suckering, de-leafing, and de-budding (taking out the male bud) to attain stable production levels (Nyariki *et al*., 2020). De-sucking is the process of removing extra and undesired suckers from banana stools that otherwise would conflict with the primary plant for nutrients and water and lower production (Bizikova *et al*., 2020). De-budding should be carried out three weeks following flowering to stop the BXW disease's insect source from spreading it (Tinra & Kawamura, 2017). As de-leafing improves the effectiveness applications of fungicides; to ensure that the bunch develops well until harvest, a trade-off must be made between removing sick leaves and preserving a minimal amount of leaf surface area (Muthee *et al*., 2019).

In Embu County, just 5% of the sampled farmers engaged in de-leafing according to Muthee *et al.* (2019) i.e the hygienic eradication of diseased black-leaf-streak disease from banana leaves (black sigatoka) (Chillet *et al*., 2013). A few farmers noted to conduct de-leafing, however, did not link the method to the control of this illness (Muthee *et al.,* 2019). On the other hand, fewer than 5% of the farmers in the sample were reported to have used other advised techniques, including as pruning, mulching, managing pests and diseases, de-suckering, mat-tacking, de-navelling, and bagging (Muthee *et al.*, 2019). Ndiritu *et al*. (2013) also noted that certain banana growers in Murang'a County showed enough awareness of the advised management techniques but were hesitant to use them because of the high costs and lack of technical expertise.

Joshi *et al*. (2020) reported that there was no water logging issue and that 91% of respondents possessed a drainage system in their banana orchard. Shrestha & Giri (2012) revealed that the district of Kailali had 37% of its farmers with irrigation issues as Poudel (2011) noted that a key issue for banana growers in Nawalparasi was a lack of irrigation. Lack of irrigation implies moisture stress affects yields, which reduces yields as weeds and bananas battle for nutrients and water and in addition, when a few weeds are present in banana orchards, they also contain bugs and illnesses that result in significant production losses (Tinzaara *et al*., 2018). Joshi *et al*. (2020) found out that a majority of farmers irrigated their fields by using canals to pump some groundwater and other water; approximately 81.5 % of the respondents did not supply irrigation water regularly as only

2.5% of the farmers had embraced water-saving techniques such as drip irrigation. It was also noted that about 62.1% of respondents supplied bananas with clear, clean water plants that is devoid of the damaging microorganisms (Joshi *et al*., 2020).

The rate of recommended methods' implementation by banana farmers was found to be low by Woniala & Nyombi (2014) in Uganda. In a study by Muthee *et al.* (2019), only 13% and 12% of the respondents were found to be implementing their orchards with irrigation and weeding, respectively, despite the fact that the respondents were chosen based on the number of functioning irrigation schemes in each of the four sub-counties. According to Nyombi (2013), for bananas to grow properly, they need 1300mm of annual rainfall, or 25mm per week and therefore bananas should routinely receive 200 to 220 mm of water each month to provide optimum yields (Muthee *et al*., 2019). In Sri Lanka, only 33% of potato growers had conducted a soil test every two years, as only 26% of farmers had used the necessary fertilizer (Senanayake & Rathnayaka, 2015). A rich, drained loam soil with a highest humus level and a pH level between 5.6 and 7.5 is necessary for banana cultivation (Joshi *et al*., 2020). Bananas need a lot of nitrogen and potassium to keep yields high (Senanayake & Rathnayaka, 2015). Crop damage and low yield are brought on by drought, water logging, and insufficient sunlight (Karienye *et al*., 2020). Joshi *et al*. (2020) noted that 48.5% of the respondents had tested the soil in their banana orchards as part of a mobile soil testing program set up in their region and in the process found out that about 26.2% of those surveyed didn't apply the fertilizer in the time interval advised.

Gautam & Tiwari (2007) noted that after establishing sucker plants, nitrogen should be applied two, four, and six months later because it has been documented that applying more nitrogen at once causes nitrification and leaching. Potash should also be used when sucker planting and bunch formation take place. In a study by Muthee *et al.* (2019), majority of farmers in Embu County seemed to be unaware of the significance of soil testing for banana production whereby Runyenjes had the highest percentage (40%) of farmers who had tested their soil in the previous five years, followed by Manyatta (38%) as Mbeere South (10%) and Mbeere North (12%) sub-counties had comparatively lower rates of the practice. However, the majority (90%) of these farmers stated that they urgently needed instruction on soil testing and managing soil fertility for banana cultivation (Muthee *et al.*, 2019). As just 15% of the respondents were found to be fertilizing their banana plants with manure and other fertilizers, Wahome *et al.* (2021) identified this as one of the main factors causing decreased banana yields in Embu County whereby none of the few farmers that fertilized their orchards with fertilizer used bio-fertilizers. Nutrients from cattle dung combined with urea at a 50% substitution yields the maximum productivity (52%) (Meya *et al*., 2020). Farmers in India identified lack of manure and high price of inorganic fertilizers as the main barriers to their use (Ganapathi & Dharmatti, 2018). In addition to potentially reducing yields, neglecting to weed banana orchards is known to host pests that result in significant production losses (Isaac *et al*., 2012).

Joshi *et al*. (2020) revealed that, with the exception of 5.8% of farmers, practically all recycle crop leftovers (such as pseudo-stems and leaves) into organic manure. The equipment used in banana growing, such as the sickle, shovel, and other tools, were not safely regulated by about 73.7% of the farmers as majority of them merely used water to clean the equipment, but others also used solar energy to dry it out after use to sterilize it (Joshi *et al*., 2020). Rijal *et al*. (2018) stated that while applying the insecticide, only 34% of farmers utilized masks and 14% of farmers used no personal protective equipment at all. About 26.3% of respondents kept their equipment in a safe state of repair, while 39.8% of the respondents kept track of when pesticides were used (Rijal *et al*., 2018). According to Joshi *et al*. (2020), in order to handle and apply pesticides, around 87.4% of the respondents mobilized an experienced worker. The knowledge of registered or prohibited pesticides was unknown to almost 35% of the respondents and when spraying chemical pesticides, only 44.7% of the respondents employed all of the personal protective equipment; other respondents used some but not all of it (e.g. mask only, mask and boot only) (Joshi *et al*., 2020).

NHPC (2017) noted that in the Kailaki district, only banana leaves were utilized to cover the bananas during transportation but it was believed that this would physically harm the banana fruits and therefore bananas suffered a post-harvest loss of roughly 10-15%, which was higher than that of mango, citrus, and apple. A harmful microorganism infestation could result from failure to follow post-harvest procedures as Khadka *et al*. (2017) indicated that the use of post-harvest handling techniques in tomatoes decreases the number of aerobic bacteria, coliform bacteria, mold growth, and self-life. Joshi *et al*. (2020) remarked that every responder disposed of farm trash, including nutrients, empty pesticide containers, tanks, and others, in a safe manner noting that a majority of them used the municipal or metropolitan city's rubbish collection vehicle to send these wastes as some of them burned the rubbish, while others buried it in the hole in view of taking steps to ensure that children and animals were not harmed by this trash.

In a study by Muthee *et al.* (2019), the growers of bananas were found to be seriously hampered by a number of pests and diseases whereby nematodes (26%), banana weevil (26%), banana thrips (24%), and moles (21%) are the main pests of bananas in Embu County. The findings of Wachira *et al*. (2013), who noted that nematodes, banana weevil, and thrips are among the main pests restricting banana productivity in various growing districts of Kenya, corroborated this observation. Nematodes, in particular *R. similis*, damage secondary and tertiary banana roots' feeding roots, which severely shortens the productive life of banana fields and reduces yields by more than 50% (Isaac *et al*., 2012). However, most of this studies shade light on the knowledge on tissues culture banana production but fail to show us the influence of the knowledge level to tissue culture banana adoption.

2.6: Advantages of Adoption of Tissue-Cultured Bananas

The choice of whether to or not to use the suggested methods for banana production rests with the farmers (Ainembabazi & Mugisha, 2014). The decision by smallholder farmers to embrace and maintain the technology, revert to the old methods, or reject and maintain the rejection of the technology is supported by the sustainability of the yield (Murongo *et al.*, 2018) . Growing bananas is one of the primary sources of income and a mainstay food for Kenya's rural small-scale farmers (GoK 2011). Banana production contributed 38% of Kenya's total fruit value in 2012 (GoK, 2012). Most small-scale banana growers are growing more reliant on the proceeds from selling their produce (Wambugu & Kiome, 2001). When cultivating bananas for the first time, using tissue-grown plants can prevent pests from spreading to freshly planted regions (FAO, 2001). According to Kikulwe *et al*.

(2012), the application of technology enhanced the banana industry's profitability and efficiency. Kabunga *et al*. (2012) found no statistically significant variation between the mean produces for non-adopters and adopters but stressed that after removing negative selection bias there could be a major impact on the tissue culture yields. According to Muyanga (2009), non-tissue culture banana variants have surpassed tissue culture bananas in size and output. Adopting tissue culture has the benefit of improving crop sales revenue and food supply and also raises funding in the form of government access and gives women and young people the opportunity to work (Wambugu *et al*., 2008). By expanding adoption, the current issue of food insecurity at the household level can be resolved since bananas will become a convenient food supply (Chandler, 1995). Many people in Murang'a County, especially in the Makuyu area, have been engaged in the banana tissue culture industry, both directly and indirectly (Olwande *et al*., 2015). Qaim (1999) studied the effects of Kenyan banana biotechnology and realized that tissue culture banana engineering offers the underprivileged several opportunities. Although advantageous, Qaim (1999) emphasizes that adopting new technology results in a significant rise in manufacturing costs.

A study by Nguthi (2007) evaluated the effects of smallholder farmers in rural Kenya using tissue culture bananas in the context of HIV and AIDS whereby the results showed that the first adoption decision was influenced by money and land tenure security, regardless of the individual farmer's HIV/AIDS status. As a result, using tissue culture banana plantlets can aid farmers in switching from subsistence to small-scale commercial cultivation (Murongo *et al*., 2018). Muyanga (2009) studied the economic effects of tissue cultured bananas on smallholders in Kenya where the goal of the study was to determine whether growing tissue culture bananas in Embu, South Imenti, Murang'a, Maragwa, and Kirinyaga was increasing household income and food security and the findings of this study revealed that while 75% of the farmers had accepted the tissue culture banana technology, just 3% had become experts in its application an indication that either these farmers didn't like taking chances and were unwilling to give up their native types in favor of bananas grown in tissue culture, or they were not yet entirely convinced of the technology's superiority.

2.7: Research Gaps

From the literature reviewed, there hasn't been any effort made to increase the target beneficiaries' awareness of new technologies, and there hasn't been any capacity building for them either, which could result in misunderstandings that would delay or prevent the adoption of the technology. Even though the soils in the research area are fertile and the climate is adequate in terms of temperature and precipitation, there is a dearth of knowledge surrounding the underlying causes of why farmers have not yet used the tissue culture banana technique.

CHAPTER THREE: METHODOLOGY

3.1: Description of the Study Area

South-western Kenya's Kisii County is located in the Nyanza region with 1,266,860 people living in the county (KNBS, 2019). The county has a total land size of 1,332.7 km^2 and is located between 00^0 30' and 01^0 0' South Latitude and 34^0 38' to 35^0 0' East Longitude (GoK, 2018). The study took place in Kitutu Chache South sub-county. The area receives 1500 mm of rain annually, with the heaviest showers falling from March to June. The temperature swings from 15°C to 20°C at night and from 21°C to 30°C during the day (GoK, 2018). A total of 75% of the area is covered in soils from a red volcano that are renowned for having substantial organic content (GoK, 2018). The sub-county has a total of 154,175 inhabitants Figure 3.1 depicts Kitutu Chache South sub-county (KNBS, 2019).

Principal crops farmed in Kisii County are horticulture crops, maize, beans, bananas, tea, sugarcane, potatoes, and coffee. Among the banana cultivars are Cavendish, “Williams” (Ong'oncho), and "Robusta" (Egesukari) "Gran Nain" (Ong'ombe) and "Dwarf Cavendish" (Ekegusii) “Bananas seorita” (Epogopogo) “Big Michel” (Egesukari). Tilapia and catfish are the principal fish farmed in the area's ponds, where fish farming is also performed. Dairy cattle, Zebu, goats, sheep, and poultry are among the predominant animal breeds in Kisii County. However, due to small land holdings, it is vital to encourage the growth of both conventional food crops and horticultural. The limited number of land holdings is the result of land being divided into small, unprofitable portions as a result of the growing population. This has significant implications for the sub-county’s and the county's capacity to guarantee that its residents have access to food; consequently, actions like enacting land use regulations and stepping up the use of contemporary farming methods ought to be taken.

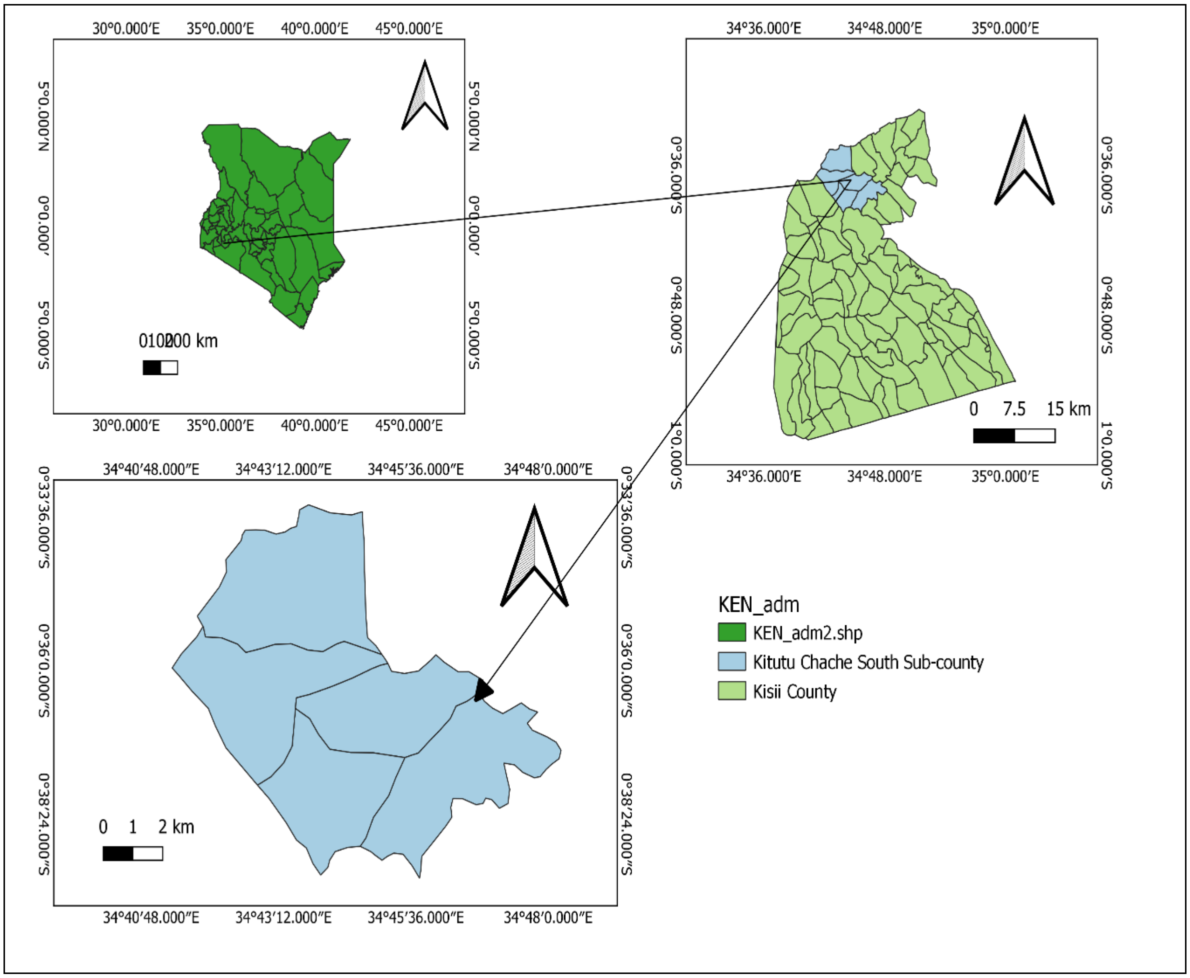

Figure 3.1: Map of the study area. (Modified from Kenya administrative units)

3.2: Research Design

In this study, an outline for descriptive research was used. Surveys helped in providing the answers to the questions that were gathered through questionnaires and interviews, and checklists for observation were used.

3.3: Target Population

The 402 registered banana farmers who grow bananas for both food and profit were the subject of this study.

3.4: Sampling Procedure

Simple random sampling was performed for information gathering from the responses for the study. Due to the farmers being distributed inefficiently throughout the almost identical wards that make up Kitutu Chache South Sub- County, an unequal sample size was picked at random from each to create trustworthy data. Purposive sampling technique was employed to recruit all KARLO and Agricultural Officers at the ward level due to the well-known fact that these individuals are replete with knowledge about agricultural systems within the study area.

3.5: Sample Size

Using the formula $n = N / [1 + Ne^2]$ from Yamane, (1967), the sample size was decided. Where N is the target population, n is the sample size, e stands for the standard error, which is typically 0.05. $402/1+402 \times 0.05^2 = 200$

3.6: Data Collection

The information for this study was gathered using secondary sources as well as primary sources. Primary data utilized survey forms, interview schedules, and checklists for observation. Direct observations were undertaken to collect relevant non-verbal data. To obtain information on the socioeconomic factors, benefits, and impact of knowledge level on the adoption of small-scale tissue culture, questionnaires were administered to banana farmers. Secondary data was obtained through direct contact interviews with KARLO executives and agricultural extension specialists with a guiding set of questions were conducted to gain their thoughts on the factors affecting the uptake tissues culture banana technology. The resource went into detail on the socioeconomic factors that affect the banana tissue culture adoption, the advantages, as well, difficulties small-scale farmers encounter, their level of competence, and potential remedies for these problems. Throughout the study, observations were made to catalog important aspects of farming. These included the various banana varieties that have been grown, other crops that have been raised, and available field techniques. While undertaking fieldwork, notes were taken as part of the data required from the industry that were used to develop conclusions from this study.

3.7: Validity and Reliability

The research instruments were tested before the actual data collection and then modified as per the suggestions given during pre-testing. Randomly chosen farmers from Kitutu

Chache South Sub-County were interviewed in the pre-testing exercise. The survey itself didn't include the respondents who took part in the pre-test exercise. To prevent confusion of being tested again, they were marked by use of assigned numbers at the entrance to their homesteads. The divided half approach method was employed to evaluate the instrument's reliability. This needed splitting the test into two halves using an even- and odd-numbered numbering system, and correlating the answers. This made it possible to determine the extent to which tools' items suggested similar replies. According to Kasomo (2015), if elements considerably compare to one another, assurance about the dependability of the overall scale is created. Cronbach's coefficient was used in the study to evaluate the created items' scale reliability. Since it exceeded 0.7, the reliability test result of Knowledge items 0.992 and benefits items 0.994 was considered acceptable, and any scale above that value is also acceptable.

3.8: Data Analysis

Farm socio-economic characteristics were related to tissue culture banana adoption using comparative statistical procedures, including means comparisons (numeric characteristics) and Chi-square tests for categorical variables using SPSS procedures. For numeric characteristics (Land Size Under Banana, Hh Size and Farming experience) means between adoption categories were significant at $p<0.05$ in T-test. Chi-square tests were conducted between adoption and categorical variables (credit access, age categories, education levels, marital status, extension access, seedling affordability, land tenure, and labour type) and significant relationships between the variables were declared at $p<0.05$.

The study used a logistic regression model using maximum likelihood estimation to estimate the probability of tissue culture banana being adopted by farmers as influenced by several socio-economic characteristics. The Statistical Package for Social Sciences (SPSS) was used to estimate the binary logistic regression (Norusis, 2008). The "logit" is the natural log odds of tissue culture banana adoption, Y=1 which signified the absence or presence of tissue culture banana in smallholder farms while X denoted a vector of explanatory socio-economic variables as follows: Age, Marital status, Occupation, Labour, Education, Farming experience, Farm size, Credit access, and Input access (Equation 1).

logit [p] = ln [odds (Y = 1)] = $\ln\left[\frac{p}{1-p}\right]$

logit [p] = $\beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \beta_5\chi_5 + \ldots\ldots.\beta_i\chi_i$ Equation **(1)**.

Several model tests were used to validate the viability of the binary regression model. The Hosmer and Lemeshow test of goodness of fit evaluated whether the model was a good fit to the data whereby a large p value approaching is better. Nagelkerke's R^2 is a coefficient of determination that is similar to R^2 value in linear regression models, but estimated for models with categorical response variables. The percentage accuracy in classification value tests the percentage of cases that can be classified correctly classified in a response category after addition of independent variables added (Norušis, 2008). Table 3.2 shows the variable descriptions for the regression model. The response categories for categorical variables were re-classified into dummy variables as follows.

Table 3.2: Description of regression variables influencing tissue culture banana adoption

Parameters	**Description**	**Response categories and units**	**Variable type**
Age	Age of the HH	1=>25 years, 0= less than 25 years	Dummy
Marital status	Marital status of the HH	1=Married, 0= Not married	Dummy
Occupation	Occupation of the HH	1=Farming, 0= non-farming	Dummy
Labour	Labour source	1=Hired labour, 0=Family labour	Dummy
Education	Education of HH	1=Above primary, 0= below primary	Dummy
Farming experience	Length of farming	Years	Continuous
Farm size	Total farm size of t HH	Hectare	Continuous
Credit access(yes)	Credit access by the HH	1=Has access, 0= No access	Dummy
Input access (yes)	Credit access by the HH	1=Has access, 0= No access	Dummy

The reliability of each set of questions on knowledge of tissue culture bananas and the benefits of implementing tissue culture bananas was assessed using the Cronbach's alpha test in order to ascertain the internal consistency resulting from the initial usage of a five-point Likert scale. Two-way mean comparisons were used to show the relationships between tissue culture banana knowledge items and tissue culture banana adoption. The mean comparisons were also used to display the relationship between tissue culture banana benefits and adoption. The following criteria was used to access the level of each item tested; Mode/median <3 high knowledge, mode/mean =3 moderate knowledge level, mode/mean >3 low knowledge level.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1: Socioeconomic Aspects Affecting Acceptance of Bananas Grown by Tissue Culture in Kisii County

4.1.1: Household Socio-Economic Characteristics of Respondents

The study found that 18 out of the 200 examined households, or 9% of the total, had adopted tissue-cultured bananas; indicating that the adoption rate was relatively low (Table 4.1). This shows unequivocally that despite technology's advantages, most farmers have not adopted it.

Table 4.1 Tissue Culture Banana Adoption Rate by respondents

Category	Frequency	Percentage
Non-Adopters	182	91.0
Adopters	18	9.0

This is consistent with earlier research by Wahome *et al*. (2021), who reported that despite any potential benefits of techniques for banana tissue culture, such as the quick production of a significant amount of disease-free planting materials in the Embu, Kisii, and Nyamira counties, the reality was that there was a generally low acceptance rate of this technology. Similarly, Muthee *et al.* (2019) found that just 27.8% of the studied farmers in Embu County had adopted the application of planting materials from tissue culture. Thuo *et al.* (2017) also concluded that tissue culture banana adoption was low in Kenya's Lower Eastern Semi-Arid regions, specifically in Kalawa, Kithimani, and Thaana. Chrismanto *et al.* (2019) noted that the future of the agriculture industry depends on technological advancement. The increase of agriculture industry production and sector development are supported by innovation in the sector (Lavoie *et al*., 2021). Technology has changed the conventional operating procedures in the agricultural sector since better machinery allows the sector to work in creative ways (Xu *et al*., 2021). Farmers who creatively promote the agriculture sector have the biggest effects on the growth of the economy through agricultural products (Kant & Shahid, 2022). Since the adoption of new techniques happens gradually, technology diffusion is unquestionably crucial for expanding the agriculture industry in every country (Stephens *et al*., 2018). The performance of innovators who use technology to agriculture is better than that of conventional innovators who do not apply technology (Sapbamrer *et al*., 2022). Xu *et al*. (2021) stated that the agricultural performance industry shows that less productive farmers have resistance to innovation. Technology in the agricultural sector is deemed crucial since it supports the economy's innovative expansion (Jung *et al*., 2021). Consequently, it was found that new technology benefits farmers when it is adopted in a way that is consistent with farmer mentality (Stephens *et al*., 2018). The application of technology in smallholder agriculture is supporting the increase in farm output level, and it is hoped that this will lead to the critically required change of the agricultural sector (Bachewe *et al*., 2018).

The average number of years spent on farming bananas was 9.1 (Std=4.7) with that of adopters being 3.6 years. The average size of a farm used for banana production was 2.6ha (Std=1.3), ranging from 1ha to 6ha. According to FAO (2013), this indicates that they were small-scale cultivators. All farmers were seen to practice mixed farming, in which crops such as napper grass, maize, cassava, beans, onions, kale, sweet potatoes, and others were cultivated alongside bananas rather than on separate stands. This was due to the clusters' dense population and considering that the bulk of residents were small-scale farmers. Land subdivisions resulted from increased population among the main inheritors of their parents' land, which was the main reason for the small sizes of land used for banana farming.

The occupants per family had a mean of 5.5 (Std=2.0) (Table 4.2). The house hold size for non-adopters (5.6) was significantly higher than that of adopters (1.8) (Table 4.2). The study found that 37.5% of the respondents, or the majority of banana producers, were between the ages of 36 and 45 years. This was linked to the fact that at this age, people depend on their judgment and also on their property, as opposed to young people who are were to be only partially dependent. With 31.5%, attributable to the fact that this is the stage of transition from independence to dependence, the youth (26–35 years) were close behind.

Table 4.2 Household Socio-Economic Characteristics of the Respondents

Parameter	Description	Non-Adopters	Adopters	Total
Age	Up to 25	6 (3.3)	1 (5.6)	7 (3.5)
	26-35	55 (30.2)	8 (44.4)	63 (31.5)
	36-45	69 (37.9)	6 (33.3)	75 (37.5)
	46-55	30 (16.5)	1 (5.6)	31 (15.5)
	56-65	17 (9.3)	2 (11.1)	19 (9.5)
	Above 65	5 (2.7)	0 (0)	5 (2.5)
Gender	Male	108 (59.3)	13 (72.2)	121 (60.5)
	Female	74 (40.7)	5 (27.8)	79 (39.5)
Marital status	Married	159 (87.4)	16 (88.9)	175 (87.5)
	Single	4 (2.2)	1 (5.6)	5 (2.5)
	Divorced	3 (1.6)	0 (0)	3 (1.5)
	Widowed	16 (8.8)	1 (5.6)	17 (8.5)
Education level	Primary	3 (1.6)	1 (5.6)	4 (2)
	Secondary	79 (43.4)	11 (61.1)	90 (45)
	Tertiary	100 (54.9)	6 (33.3)	106 (53)
Extension services	Yes	22 (12.1)	18 (100)	40 (20)
	No	160 (87.9)	0 (0)	160 (80)
Seedlings affordability	Yes	39 (21.4)	12 (66.7)	51 (25.5)
	No	143 (78.6)	6 (33.3)	149 (74.5)
Land acquisition	Inherited	180 (98.9)	15 (83.3)	195 (97.5)
	Purchased	2 (1.1)	3 (16.7)	5 (2.5)
HH occupation	Farming	85 (46.7)	6 (33.3)	91 (45.5)
	Employed	51 (28)	7 (38.9)	58 (29)
	Business	46 (25.3)	5 (27.8)	51 (25.5)
Access to credit	Yes	62 (34.1)	12 (66.7)	74 (37)
	No	120 (65.9)	6 (33.3)	126 (63)
Labour availability	Family	82 (45.1)	6 (33.3)	88 (44)
	Hired	0 (0)	1 (5.6)	1 (0.5)
	Hired & Family	100 (54.9)	11 (61.1)	111 (55.5)
Access to farm inputs	Yes	43 (23.6)	17 (94.4)	60 (30)
	No	139 (76.4)	1 (5.6)	140 (70)

Values are frequencies followed by column percentages in parenthesis.

Parameters	No Adoption	Adopted	Total	Sig
Land Size Under Banana in Ha	2.6 ±1.3(182)	2.4 ±1.2(18)	2.6 ±1.3(200)	ns
Hh Size	5.6 ±2.0(182)	4.7 ±1.8(18)	5.5 ±2.0(200)	0.05
Farming experience	9.3 ±4.7(182)	7.2 ±3.6(18)	9.1 ±4.7(200)	ns

Values are means, followed by standard deviations and number of farmers in parenthesis.

Due to the high dependence on the household head at this point, the range of up to 25 years records a low proportion. Older people over 65 years tend to depend on their offspring, which is a consequence of the low level of farming activity—2.5% in this case.

Among non-adopters, most of the farmers were of the age category 26-45 years, comprising 69% of all farmers. Based on the age and adoption argument, majority of adopters were of the age range of 26 to 35 years (Table 4.2), accounting for 44.4% of all adopters. The elderly appeared to be resistant to the new technology.

Results showed that 60.5% of banana farmers were men, compared to 39.5% of women. Males made up 59.3% of the non-adopters, compared to their female counterparts, who made up 40.7% of the total. On comparing adoption by gender, it was found that men made up the majority at 72% of adopters. This was due to the fact that in a natural African setting, most households are headed by men who play important roles in family decision-making. As they are the owners of the land, they have a bigger say on its usage. Women are entitled to use the land and perform majority of the domestic and agricultural work.

Results showed that 87.5% of all banana growers and 88.8% of banana growers who had implemented tissue culture were married. This shows that majority of married persons work in the banana industry (Table 4.2). Because possessing a spouse boosts a household's access to labour, which is necessary, it is significant in technology adoption. Achieng (2017) explained that couples with both spouses working full-time on the farm had a higher likelihood of utilizing ISFM technologies ever since they had more manpower than couples with only one spouse working full-time on the farm did.

Majority of banana farmers in the research region had graduated from college, with a 53% completion rate followed by the secondary school with a 45% completion rate (Table 4.2). For the non-adopters, 54.9% had completed their tertiary education as 43.4% had completed their secondary education. When adopters' knowledge level was taken into account, majority of them had a high level of understanding and had completed secondary school, making up 61.1% of the total whereas 33.3% had attained tertiary (Table 4.2). This suggested that the majority of the area's educated population engaged in banana farming locally.

The findings showed that 80% of farmers were unable to use extended services. For the non-adopters, 87.9% lacked access to services for extensions. The lower number of extension officers in the area was to blame. All farmers who had embraced the tissue culture banana technique had access to extension services (Table 4.2). This was because they were simply able to contact them since they had received the seeds from the county government through the extension officials.

The results found that majority of all respondents, (74.5%), and 78.6% of non-adopters reported a negative indication of being able to buy seedlings (Table 4.2). This was ascribed to the reality that majority didn't have access to loans and the fact that most of them live nearly attached to the poverty line. Individuals who had already embraced the technology reported a 66.7% positive indication of affording the seedlings if they were offered. This was attributed to the fact that most of them had the ability to get loan since other than banana farming, they engaged themselves in income generation activities that gave them securities for loans. However, it was noted that there was a problem in access to the seedlings which was attributed to the fact that there was no certified source of tissue seedlings within the area and the surrounding environments. The study found that 97.5% of all banana farmers, 98.9% of non-adopters and 83.3% of the adopters received their land by inheritance. This came as a result of the traditional way of life of acquiring land from the parents. This land was readily available and the need to lease land decreased due to that fact.

Majority of household heads, 45.5% and 46.7% of non-adopters were farmers as 38.9% of the adopters were employees (Table 4.2). Farming had been a source of livelihood for majority of the Kisii community hence the reason for its dominance. The study found out that 63% of all farmers and 65.9% of those who did not follow the strategy had no access to loans whereas 66.7% of the adopters had access to credit (Table 4.2). Banana adoption and improvement in the deployment of agricultural innovations requires resources, but this was constrained by the lack of financial facilities. This was ascribed to the fact that small-scale farmers were denied loans by commercial banks due to a lack of security or repayment capacity. Banana growers reported that there was a propensity for farmers to accept agricultural innovations provided they had access to financing that would allow them to pay for farm supplies, pay labour, and obtain other necessary resources for implementing technologies to improve banana production.

The study found out that for all farmers, 55.5%, 54.9% of non-adopters and 61.1% of adopters used both hired and family labour (Table 4.2). Labour supplements were as a result of a smaller number of family members and also other duties such as jobs hence some families preferred to have labour out of the family in order to continue with their official duties. Also, responders stated that their negative anxiety of adopting tissue culture bananas due to the strong demand for labour practices in banana cultivation. The results showed that 70% of all farmers and 76.4% non-adopters were denied access to farm inputs as farm inputs were found to be available to 94.4% of adopters (Table 4.2). This low access was attributed to the fact that most famers had no access to finances that could enable them purchase the farm inputs due to poverty hence could not afford security for loans if offered any.

4.1.2: Social Economic Factors Influencing Tissue Culture Banana Adoption

Many factors influence African smallholder farmers' adoption of new technologies (Jha *et al*., 2019). This is because smallholder farmers must acquire knowledge both on how to use new technology and methods and how to integrate them into existing systems (Salami *et al*., 2010). In this study, household size was found to be significantly influencing adoption of banana tissue culture in the research area, p=0.05 (Std=1.8), an indication that the more the number of individuals in a family, the more likely the adoption due to increase in labour (Table 4.3). Family size was found to be a favorable and important factor in the study by Wanyama *et al*. (2016) suggesting that adoption of tissue-culture bananas is more likely to rise with family size increase. In the research by Claessens *et al*. (2012), the number of people in a smallholder farmer's home was determined to be a proxy for both labour availability and financial commitment.

Access to extension services recorded a strong relationship with banana tissue culture adoption rates in the study area, p=0.000 (χ^2=79.1). Farmers that receive more extension services are more prone to adopt tissue culture banana technology because they can learn more about growing bananas in tissue culture. An effective extension system is essential for disseminating knowledge about better practices and promoting adoption of these technologies (Kirimi *et al*., 2023). Adejuwon (2019) and Oyinbo *et al*. (2019) observed that smallholder farmers adopted new technology more readily when extension services were available to them in that the specialists in extension aid in educating small-scale farmers about new technologies and their benefits thus speeding up smallholder farmers' embrace of technology. The results by Sarker (2016) also indicated that a productive and successful extension scheme is a crucial instrument for the transmission of knowledge about better practices as well as a more successful adoption of these technologies. This is hand in hand with Wahome *et al*. (2021) who found that one of the causes of the low productivity was inability to obtain agricultural services, such as communication with extension workers or agents.

Table 4.3 Social Economic Factors Affecting Tissue Culture Banana Adoption

Parameter	**Ch-square/ANOVA**	**Sig**
Age	3.193	0.670
Extension services	79.1	**0.000**
Gender	1.137	0.210
Land acquisition	16.3	**0.006**
Education level	3.835	0.147
Seedlings affordability	17.6	**0.000**
Marital status	1.242	0.743
Access to farm inputs	35.9	**0.000**
HH occupation	1.351	0.509
Access to credit	7.468	**0.007**
Labour availability	10.735	**0.005**

Parameters	**No Adoption**	**Adopted**	**Total**	**Sig**
Land Size Under Banana in Ha	2.6 ±1.3(182)	2.4 ±1.2(18)	2.6 ±1.3(200)	ns
Hh Size	5.6 ±2.0(182)	4.7 ±1.8(18)	5.5 ±2.0(200)	**0.05**
Farming experience	9.3 ±4.7(182)	7.2 ±3.6(18)	9.1 ±4.7(200)	ns

Values are means, followed by standard deviations and number of farmers in parenthesis.

The adoption of tissue culture bananas was significantly correlated with the cost of the seedlings in the study area, p=0.000 (χ^2=17.6). This was an indication that there is a likelihood of more individuals adopting the technology with a decrease in the costs accrued in the production process since they will be able to afford it. Michalscheck *et al*. (2018) and Akrofi *et al.* (2019) noted that the high prices attached to agricultural innovations frequently prevented their implementation. Consequently, Senyolo *et al*. (2018) observed that smallholder farmers in Africa tended to steer clear of expensive to acquire and maintain technologies. Smallholder farmers were seen to accept new technologies depending on how simple in terms of the needs of the body and mind, they are to be used, which is consistent with the features of technology that were determined to affect adoption (Smale & Mason, 2014).

The adoption of tissue culture bananas was significantly correlated with land acquisition in the study area, p=0.006 (χ^2=16.3) (Table 4.3). It can be seen from this study that adoption of the technology increases with a shift from purchased land to inherited land. This was attributed to the fact that inherited land is free of rent hence reducing the production expenses of banana tissue culture as a result of money paid for access to farms. Access to credit was found to be important in the adoption of banana tissue culture in the research area, p=0.007 (χ^2=7.468) an indication that a farmer has a higher chance of adopting tissue accumulation banana-based technologies with ease of access to credit. The study's findings are consistent with those of Sharma *et al*. (1997) who reached the conclusion that a home's capability to absorb risks was more strongly correlated with its ability to acquire credit facilities. Similarly, Nyang'au (2019) found that some farmers lacked access to financial resources to adopt banana tissue culture technology. Out of the 128 articles examined, 81 pointed to finance as a factor that affected the adoption of new technology (Fadeyi *et al.*, 2022). As a result of the bulk of these technologies' high costs of both acquisition and maintenance, studies have revealed a strong association between finances and African smallholder farmers adopting technology (Habtemariam *et al.*, 2019). Financial support has been shown to enable smallholder farmers to buy, use, and maintain innovative technologies (Fisher & Carr, 2015). Smallholder farmers can also use financing to pay employees, buy farmland, and obtain the necessary education and skills. This will make it easier for smallholder farmers to adopt new technologies. It was observed that small-scale farmers rely on funding not only to adopt new technology but also to investigate fallback options in the event that the new technology fails (Oyinbo *et al.*, 2019).

Labour availability was found to be significant to the use of banana tissue culture in the research region, p=0.005 (χ^2=10.735). This indicated that a rise in the labour force raises the likelihood of adopting the technology in banana cultivation since banana cultivation tends to utilize a lot of labour in farm operations. Findings of Nyang'au (2019) study found that growers' adoption of improved banana techniques had been impacted by the labor shortage. Access to farm inputs was noted to have a major impact on the application of tissue-culture bananas in the study area, p=0.000 (χ^2=35.9). A farmer is more likely to adopt tissue culture technology with access to farm inputs. With access to farm inputs, farmers will be able to improve banana quality during the production process hence increased adoption rate of technology since they can access the inputs responsible for improved quality production. For adoption to rise, access to better seed is crucial (Awotide *et al*., 2016). Banana tissue culture requires good care and therefore the need to supply required amounts of farm inputs to increases production hence adoption.

The logistic regression model of tissue culture banana adoption explained 52% (Nagelkerke R^2) of the variation in dependent variables according to the regression model of factors influencing adoption, and accurately classified 93.8% of cases (Table 4.4). Education and input accessibility were observed to significantly influence the adoption of tissue culture bananas. Farmers with education above the primary level were 0.002 times more likely to adopt tissue culture bananas than famers with education levels that were below primary school level. In addition, farmers with availability of inputs were 0.018 increased likelihood of adopting tissue culture banana technology than farmers without access to agricultural inputs. Farmers with higher education are more likely to comprehend information, seek out, and employ greater specific or clear understanding than farmers with less education. According to Mucheru-Muna *et al*, (2021)], a farmer is more likely to have a moderate to high level of comprehension in the issue if they have undergone the technology-related training.

Table 4.4 Binary Logistic Regression of Factors Influencing Adoption of Tissue Culture Banana

Parameters	B	S.E.	Wald	df	Sig.	Exp(B)
Age	0.073	2.57	0.001	1	0.977	1.076
Marital status	-0.475	1.234	0.148	1	0.7	0.622
Occupation	-0.449	1.195	0.141	1	0.707	0.639
Labour	-1.361	0.979	1.932	1	0.165	0.256
Education	6.323	2.591	5.956	1	0.015	0.002
Credit access	-0.718	1.182	0.369	1	0.544	0.488
Inputs	4.028	1.164	11.972	1	0.001	0.018
Constant	9.471	3.742	6.405	1	0.011	12981.01

Overall percentage correct=93.8%, Nagelkerke R^2=52%, Hosmer and Lemeshow test (sig-0.810)

4.2: Tissue Culture Banana Technology Knowledge Levels Influence on Tissue Culture Banana Adoption

4.2.1: Tissue Culture Banana Technology Knowledge levels of the Respondents

The results showed that 65.5% of all farmers and 72% of non-adopters' were not sure as compared to 66.7% of the adopters who strongly agreed (Table 4.5) hence, these findings show that adopters, compared to non-adopters, had adequate knowledge of the importance of top-dressing with 100g of C.A.N. or urea each month commencing three months after planting. For the optimal growth and output, banana plants require good soil and a plenty of soil moisture. The weight of the bunch and the number of hands depend on the growth rate the plant experiences during its first three to four months (Haifa, 2021). Therefore, it is crucial to offer the greatest care possible during this time. For optimum productivity, bananas should be fertilized often (at least 6 to 8 times per year) in soils with low fertility, such as sandy and calcareous soils. After planting and before flower differentiation, 35% of the N, P, and K application should be applied; 40% should be applied before flower emergence; and the final 25% should be done after flower emergence (Haifa, 2021).

Results showed that 64% of all farmers and 70.3% of the non-adopters were not sure as compared to 66.7% of adopters who strongly agreed that C.A.N. or urea should be administered in a band 2 feet outside of the plant and covered with dirt (Table 4.5). The findings indicated that adopters had more in-depth knowledge. CABI (2019) noted that a ring or shallow furrow in the shape of a ring about 2 feet away (60 - 100 cm) from the mat forked from around the mat are required for good banana farming practices for sprinkling in the fertilizer and covering with dirt. It is common knowledge that the plant may more quickly receive nutrients given externally thanks to forking. Many of the nutrients in the soil will vanish into the air or be washed away by rain when the application of fertilizer is done on top of the soil. Therefore, dirt is used to cover the fertilizer once it has been placed in the forked area to avoid the disadvantage (CABI, 2019).

The study found that 66% of all respondents and 72.5% of non-adopters were unsure as 72.2% of adopters had strong agreement that, when all other factors are held constant, efficient fertilizer use accounts for 50% of the increase in tissue cultured banana production (Table 4.5). These findings demonstrate that the approach was well understood by adopters as compared to non-adopters. In comparison to the control, soil improvements considerably boosts banana shoot biomass and yields (Zhang *et al*., 2020). The fast-growing banana plant needs high and constant food and water supplies to maintain a year-round cycle and guarantee a high economic yield. Although the soil may provide some of these nutrients, fertilizer application is typically necessary to meet the needs of the plant and to achieve profitable production (Santosh & Tiwari, 2017).

Majority, 64.5%, of all respondents and 70.9% of non-adopters were unsure as 66.7% of adopters strongly agreed that the best strategy to increase soil fertility and increase banana production may be to use the right combinations of organic and mineral fertilizers (Table 4.5). According to these findings, those who adopted the idea were shown to be more knowledgeable than those who did not. According to Gram *et al*. (2020), there have been various reasons put forth. In the beginning, combined sources of organic and mineral nutrients enable smallholder farmers to apply sufficient and appropriate ratios of major and minor nutrients, which is essential to maintain soil fertility and crop output over the long term. Second, in addition to its obvious benefits for soil fertility, a higher organic matter content in the soil also enhances other soil processes like soil biological activity and soil moisture regime. This enhances resistance to droughts in turn. Third, a unified application could perhaps provide interactions between the two resources, since the N availability synchronization and plant absorption, in terms of both amount and duration, may be enhanced through breakdown and following procedures for N mobilization. To increase yields and maintain soil fertility over the long term, it was advised to combine sources of nutrients that are both organic and inorganic (Ganapathi & Dharmatti, 2018).

Table 4.5: Tissue Culture Banana Knowledge Levels of the Responds

Knowledge item	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total
Non-Adopters						
It's a must to top-dress my plant every month starting three months after planting with 100g of C.A.N./urea.	0(0.0)	3(1.6)	131(72.0)	23(12.6)	25(13.7)	182(100.0)
Apply C.A.N. or urea in a strip two feet away from the plant, then cover it with earth.	0(0.0)	5(2.7)	128(70.3)	23(12.6)	26(14.3)	182(100.0)
50% of TCB production attributed to efficient fertilizer use	0(0.0)	4(2.2)	132(72.5)	21(11.5)	25(13.7)	182(100.0)
The greatest strategy to influence soil fertility is by combining organic and mineral fertilizers.	0(0.0)	3(1.6)	129(70.9)	25(13.7)	25(13.7)	182(100.0)
Mineral fertilizer and organic fertilizer should be used in a 1:1 or 50/50 ratio.	0(0.0)	3(1.6)	131(72.0)	22(12.1)	26(14.3)	182(100.0)
Spacing banana is a necessity to lessen competition for minerals and water	1(0.5)	2(1.1)	128(70.3)	25(13.7)	26(14.3)	182(100.0)
Plant with a depth of 3 × 3 feet and an interplant spacing of 2.5 x 2.5 meters or 3 x 3 meters.	0(0.0)	3(1.6)	131(72.0)	20(11.0)	28(15.4)	182(100.0)
Manure and fertilizer should be combined with topsoil in a ratio of 100g DAP and 1-2 debes of manure each hole.	1(0.5)	4(2.2)	129(70.9)	24(13.2)	24(13.2)	182(100.0)
There is a need to de-leaf leaves that have the disease "black-leaf-streak"	0(0.0)	5(2.7)	129(70.9)	20(11.0)	28(15.4)	182(100.0)
Using suckers, a typical farming technique, raises the danger of banana illnesses and pest infestations, which can reduce productivity.	0(0.0)	4(2.2)	129(70.9)	23(12.6)	26(14.3)	182(100.0)
Tissue culture banana is pest-and-disease free	0(0.0)	3(1.6)	130(71.4)	25(13.7)	24(13.2)	182(100.0)
Tissue culture banana mature early and uniformly	3(1.6)	95(52.2)	40(22.0)	20(11.0)	24(13.2)	182(100.0)
Adopters						
It's a must to top-dress my plant every month starting three months after planting with 100g of C.A.N./urea.	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Apply C.A.N. or urea in a strip two feet away from the plant, then cover it with earth.	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
50% of TCB production attributed to efficient fertilizer use	13(72.2)	5(27.8)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
The greatest strategy to influence soil	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)

fertility is by combining organic and mineral fertilizers.						
Mineral fertilizer and organic fertilizer should be used in a 1:1 or 50/50 ratio.	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Spacing banana is a necessity to lessen competition for minerals and water	13(72.2)	5(27.8)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Plant with a depth of 3 × 3 feet and an interplant spacing of 2.5 x 2.5 meters or 3 x 3 meters.	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Manure and fertilizer should be combined with topsoil in a ratio of 100g DAP and 1-2 debes of manure each hole.	13(72.2)	5(27.8)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
There is a need to de-leaf leaves that have the disease "black-leaf-streak"	12(66.7)	5(27.8)	1(5.6)	0(0.0)	0(0.0)	18(100.0)
Using suckers, a typical farming technique, raises the danger of banana illnesses and pest infestations, which can reduce productivity.	13(72.2)	5(27.8)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Tissue culture banana is pest-and-disease free	13(72.2)	5(27.8)	0(0.0)	0(0.0)	0(0.0)	18(100.0)
Tissue culture banana mature early and uniformly	12(66.7)	6(33.3)	0(0.0)	0(0.0)	0(0.0)	18(100.0)

Values are frequencies followed by column percentages in parenthesis.

Majority, 65.5% of all respondents and 72% of the non-adopters were unsure whereas 66.7% of adopters strongly agreed that the proportion should be 1:1 or 50/50 when combining mineral and organic fertilizer (Table 4.5). Comparatively to non-adopters, adopters were shown to be more informed about the approach leading to their continued adoption. Gram *et al*. (2020), over seven growing seasons, mixing mineral fertilizer made from the best organic materials (50:50) boosted agronomic efficiency by 20% and decreased losses of soil organic carbon by 18% at a total nitrogen rate of 150 kg Nitrogen/ha/season. CABI (2019) also noted that using mineral fertilizers at the proper time is crucial; applying them during dry spells is not advised. Because nutrient uptake improves with an increase in soil organic content, their effectiveness is also boosted when utilized in conjunction with organic manures. The risk of economic loss is reduced and benefits are increased with proper implementation.

To limit competition for water and nutrients during growth, 64% of all respondents and 70.3% of non-adopters were not sure whereas 72.2% of adopters had strong agreement that spacing banana plants during planting are necessary (Table 4.5). In this instance, it was realized that adopters had a greater understanding which contributed to their high adoption rate. Bananas have a high-water requirement, and additional irrigation is frequently required to maximize yield (Pawar *et al*., 2017). Originating in tropical areas, cultivation has spread to a considerably wider range of tropical and subtropical temperatures, subjecting production to prolonged dry periods (Van Wesemael *et al*., 2019). Contrary to many other crops, bananas have a cycle of development that ends with harvesting that, under ideal circumstances, takes around 10 to 14 months. However, if crop water supply is unstable, this cycle may be extended (Van Wesemael *et al.*, 2019). According to van Asten *et al.* (2011), during the banana crop cycle, a 100 mm monthly rainfall deficiency can cause a 9% reduction in bunch weight. Additionally, it has been claimed that places with annual rainfall of less than 1100 mm may have yield losses of 20–65 percent. By 2070, climate models project that due to an increase in temperature and precipitation, the subtropics and tropical highlands will have 50% more yield and land appropriate for growing bananas (Calberto *et al*., 2015).

A majority, 65.5%, of all respondents and 72% of non-adopters were unsure whereas 66.7% of adopters strongly agreed that it is advised to plant a banana plant with an interplant spacing of 2.5 x 2.5 m or 3 x 3 m and a depth of 3 x 3 ft (Table 4.5). This implies that part of the adopters' high use of the technology was there as opposed to non-adopters. CABI (2019) emphasized that it is crucial for farmers to comprehend the value of optimal spacing, as it promotes the best plant population, reduces rivalry for growth and production resources, allows sunshine penetration, and facilitates proper management activities, such as when mulching or harvesting. In terms of whether topsoil should be combined with manure and fertilizer in the amounts of 1-2 debes of manure per hole and 100g DAP, it was realized that 64.5% of all respondents and 70.9% of non-adopters were not sure as 72.2% of adopters had strong agreement (Table 4.5). Adopters had a better understanding of this method than non-adopters, which is why they continued to use the technology. CABI (2019) noted that in order to allow for water retention, it is crucial to mix all of the top soil with 2 basins of thoroughly decomposed manure before adding it to the hole (to about halfway full). In order to avoid using compact, nutrient-deficient subsoils, one should exercise caution.

The study found out that 65% of all respondents and 70.9% of non-adopters were not sure whereas 66.7% of adopters strongly agreed that there is a need to de-leaf (Table 4.5). This notes that, in contrast to non-adopters, adopters were more conscious of the necessity to hygienically remove, banana leaves that have been contaminated with the disease black leaf streak (black Sigatoka), which led to their ongoing adoption of the technology. Leaf spot infections cause a considerable loss in leaf area from flowering to harvest. Black leaf streak disease's effects on fruit that ripens too early before harvest Fruits that have a moderate infection are not ripe when harvested; fruits that have a severe infection are ripe when harvested (Ewané *et al*., 2013). From Ewané *et al*. (2013), fruit physiology was shown to be directly affected by leaf spot disease. The assimilates' availability during fruit growth appears to be a key factor in the physiological alterations that stress caused by the impacts of black leaf streak disease causes in the banana fruit. Due to this imbalance, secondary metabolites like phenolic compounds may not form as much. It had been successfully demonstrated that phenolic compounds play a part in defense mechanisms of several tissues in banana trees. Additionally, substances created by the breakdown of banana dopamine appear to be fungitoxic to C. musae (Wu *et al*., 2013). Since phenolic compounds play a part in defense mechanisms of banana trees, changes in the crown rot disease susceptibility of bananas may also be caused by these compounds. Therefore, to improve the effectiveness applications of fungicides and ensure that the bunch develops well until harvest, a trade-off must be made between removing sick leaves and preserving a minimal amount of leaf surface area (Muthee *et al*., 2019).

The outcomes demonstrated that 64.5% of respondents and 70.9% were unsure as 72.2% of adopters had strong agreement that the typical farmer practice of employing suckers increases the danger of banana illnesses and pest infestations leading to output loss (Table 4.5). Crops grown vegetatively have yield loss, decreased stand density, and shorter stand lifespan due to the accumulation of some pests and pathogens between subsequent plantings via contaminated planting material (Jacobsen *et al*., 2019). A major avenue for the spread of the banana bunchy top disease into new areas is the transportation and trade of contaminated planting materials, which is frequently correlated with lax phytosanitary standards (Stainton *et al*., 2015), whereas the illness is only locally disseminated through planting materials and aphids. Compared to the larger roots of plants generated from suckers, the tissue-cultured plantlets' roots are more vulnerable to early worm infection (Jacobsen *et al*., 2019). In China, endophytes had been used to safeguard tissue-cultured plants and lessen worm damage (Su *et al*., 2017).

The study found out that 65% of all respondents and 71.4% of non-adopters were unsure as 72.2% of adopters had strong agreement that tissue culture bananas are one of the successful pests- and disease-free technology (Table 4.5). When compared to non-adopters, it was found that more farmers who had accepted the technology knew that tissue cultured bananas were one of the successful pests- and disease-free technologies, which is why adoption was ongoing. Studies have indicated that plant community structure and compositional traits, in particular the breakdown of the plant community into hosts, nonhosts, and the range of host susceptibilities, could be used to control fungal infections (Tivoli *et al*., 2013). A plant preservation combination that can be applied to the media during the culture procedure lowers and avoids microbial contamination hence there won't be any viruses, illnesses, or pests in the planting material.

4.2.2: Tissue Culture Banana Knowledge Levels Influence on Tissue Culture Banana Adoption

Kisii county banana farmers were found to have low knowledge level on tissue culture bananas since the mean of 3.158 is an indication of low knowledge levels within the region. On subjection to mean comparison tests, all the items tested under knowledge levels were found to have a major influence tissue culture adoption banana technology (Table 4.6). The average mean for non-adopters stood at 3.338 as compared to that of adopters which was found to be 1.314. This is an indication that farmers who had adopted tissue culture banana technology had good understanding of various strategies used in tissue culture banana production as compared to non-adopters in the study area. An increase in knowledge level increases the probability of adoption.

Table 4.6: Mean comparisons of tissue culture banana knowledge items among small-scale farmers

Knowledge items	**Non-Adopters**	**Adopters**	**Total**
It's a must to top-dress my plant every month starting three months after planting with 100g of C.A.N./urea.	3.38	1.33	3.2
Apply C.A.N. or urea in a strip two feet away from the plant, then cover it with earth.	3.38	1.33	3.2
50% of TCB production attributed to efficient fertilizer use	3.37	1.28	3.18
The greatest strategy to influence soil fertility is by combining organic and mineral fertilizers.	3.4	1.33	3.21
Mineral fertilizer and organic fertilizer should be used in a 1:1 or 50/50 ratio.	3.39	1.33	3.21
Spacing banana is a necessity to lessen competition for minerals and water	3.4	1.28	3.21
Plant with a depth of 3 × 3 feet and an interplant spacing of 2.5 x 2.5 meters or 3 x 3 meters.	3.4	1.33	3.22
Manure and fertilizer should be combined with topsoil in a ratio of 100g DAP and 1-2 debes of manure each hole.	3.36	1.28	3.17
There is a need to de-leaf leaves that have the disease "black-leaf-streak"	3.39	1.39	3.21
Using suckers, a typical farming technique, raises the danger of banana illnesses and pest infestations, which can reduce productivity.	3.39	1.28	3.2
Tissue culture banana is pest-and-disease free	3.38	1.28	3.2
Tissue culture banana mature early and uniformly	2.82	1.33	2.68
Total	3.338	1.314	3.158

Mode/median <3 high knowledge, mode/mean =3 moderate knowledge level, mode/mean >3 low knowledge level

Jabbar *et al.* (2003) mentioned that a decision at a particular time to accept, reject, or postpone the decision is believed to be affected by the understanding and perception at that specific time. Once you have more information and/or have had a chance to evaluate how people who have already adopted are doing, you may decide to change your mind regarding adoption. Hörner *et al*. (2022) findings demonstrated that increase in knowledge is a significant factor in adoption where 16 to 23% of the treatment effects on adoption are attributable to increases in how-to knowledge. The initial thanks to technology diffusion, according to Kuo *et al*. (2022), is to increase public awareness of the beneficial uses of technology. Xu *et al.* (2021) observed that developed countries are using modern technology to enhance agricultural output. Sekaran *et al*. (2021) emphasized that the growth of the agriculture sector is facilitated by the spread of technology. Therefore, it is clear from the findings above that an increase in knowledge level may result in higher adoption rates.

4.3: Advantages of Adopting Tissue Culture Bananas

4.3.1: Advantages of Adopting Tissue Culture Bananas by Respondents

The results showed that 59.5% of all farmers and 62.6 % of the non-adopters agreed as 72.2% of adopters had strong agreement that tissue culture banana technology leads to increase in the total banana yields (Table 4.7). The results show that, overall, adopters were quite satisfied with the technology's value in terms of producing higher yields than non-adopters. The study found that tissue culture bananas produce 10 tons of fruit annually per acre as opposed to 5 tons from native bananas. Increased yields were attributed by tissue culture banana proponents to the crop's uniform development and growth, the crop's quicker harvest, and the higher bunch weight. They further argued that because growth was uniform, farmers could control field techniques more easily, allowing for simultaneous harvesting to satisfy market demands. These results corroborated Nyang'au (2019) observation that tissue culture farming produces higher yields.

Results showed that 58.5% of all the respondents and 61.5% of the non-adopters agreed compared to 72.2% of adopters who strongly agreed that tissue culture bananas are more income generating. As a result, we can draw the conclusion that, according to the majority, noting that the percentage of adopters who received this benefit was higher, farmers make more money from tissue cultured bananas than they do from conventional bananas (Table 4.7). They confirmed that a bunch of tissue culture bananas costs between Ksh 800 and Ksh 1600, whereas conventional kinds cost between Ksh 300 and Ksh 800. The ability to simultaneously harvest multiple bunches of bananas due to the crop's uniform and quick growth was linked to higher profitability. Additionally, compared to conventional types that did not mature consistently, banana bunches are larger and heavier. The farmer was able to increase his revenue thanks to the marketing of significant quantities of harvested bunches of tissue culture bananas. These results support the assertion that the percentage of income from bananas had an impact on tissue culture adoption. bananas to a large, indicating that money from banana sales induced farmers to grow tissue culture banana (Wanyama *et al*., 2016). Thus, the adoption rate of tissue culture banana increases as the household's share of banana earnings is bigger. This might be explained because farmers were interested in farm businesses that generated cash in order to pay their home bills. Therefore, any measures to increase household income from farm and non-farm sources, such as credit, will increase adoption of innovations, like banana tissue culture.

Table 4.7: Benefits of tissue culture banana among adopters and non-adopters

Adoption	Benefits	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total
	Increased yield	1(0.5)	114(62.6)	51(28.0)	9(4.9)	7(3.8)	182(100.0)
	More income generating	2(1.1)	112(61.5)	52(28.6)	9(4.9)	7(3.8)	182(100.0)
	Pest and Disease resistant	4(2.2)	110(60.4)	52(28.6)	9(4.9)	7(3.8)	182(100.0)
	Short Growth period	1(0.5)	113(62.1)	51(28.0)	10(5.5)	7(3.8)	182(100.0)
Non-Adopters	Promotes food security	1(0.5)	112(61.5)	52(28.6)	10(5.5)	7(3.8)	182(100.0)
	Increased yield	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	More income generating	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	Pest and Disease resistant	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
	Short Growth period	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)
Adopters	Promotes food security	13(72.2)	5(27.8)	0(0)	0(0)	0(0)	18(100.0)

Values are frequencies followed by column percentages in parenthesis.

The results showed that the majority of individuals believe tissue-cultured bananas to be a better alternative when it comes to pest and disease resistance, with 57.5% agreeing. Non-adopters' responses showed that 60.4% agreed as also 72.2% of adopters had strong agreement (Table 4.7). Respondents who have embraced tissue-cultured bananas attested that they are resistant to pests and diseases with good maintenance and field hygiene, especially while planting. Small-scale farmers said that the decline in banana production in the study area was caused by the majority of farmers planting indigenous cultivars, which are vulnerable to illnesses that reduce yields and result in significant losses. Banana production in the research area was shown to be impacted by worms, weevils, bacterial infections, and fungal diseases.

The results showed that 59% of the respondents and 62.1% of non-adopters agreed as 72.2% of adopters had strong agreement that tissue culture bananas have a shorter maturity period (Table 4.7). The results showed that because tissue culture bananas have short stems and do not need to be staked, they develop very quickly and reach maturity early. Traditional suckers, in contrast, have long stems and must be staked to prevent breakage. Small-scale farmers who had embraced the technology conducted studies that revealed tissue culture bananas grow fruits more quickly, in just 300 days as opposed to the more than 400 days required by conventional bananas. The results of this study are in line with those of Wambugu & Kiome (2001), who found that tissue culture plants develop more quickly and are therefore useful for farmers as cash crops. According to the statistics gathered, 58.5% of all farmers and 61.5% of non-adopters agreed as 72.2% of adopters had strong agreement that food security can be supported by tissue culture bananas (Table 4.7). This was ascribed to the reality that bananas are tissue cultured grow faster and at the same time the produce tended to be of good quality and quantity therefore being a faster means of availing food to the people within and outside the study area. This shows that most respondents were aware that tissue-cultured bananas support food security.

4.3.2: The Influence of the Advantages of Tissue Culture Bananas Adoption on Tissue Culture Banana Adoption

Generally, all banana farmers within the region accepted that using tissue culture bananas technology comes out with a number of benefits as the mean of 2.832 indicated high acceptance of the benefits accrued from tissue culture banana use. On subjection to mean comparison tests, all the items tested under benefits associated with using banana tissue culture were found to have a major influence tissue culture adoption banana engineering (Table 4.8).

Table 4.8: Mean comparisons of tissue culture banana benefit items among small-scale farmers

	Tissue culture banana adoption		
Benefits	**Non-Adopters**	**Adopters**	**Total**
Increased yield	2.49	1.28	2.38
More income generating	2.49	1.28	2.38
Pest and Disease resistant	2.48	1.28	2.37
Short Growth period	2.5	1.28	2.39
Promotes food security	2.51	1.28	2.39
Total	2.494	1.28	2.832

Mean <3 high acceptance, mean=3 moderate acceptance, mean >3 low acceptance

The average mean for non-adopters stood at 2.494 as compared to that of adopters which was found to be 1.28. This is an indication that farmers who had adopted tissue culture banana technology had an upper hand to the benefits realized due to tissue culture banana production as compared to non-adopters in Kisii County hence favouring continued adoption of the technology highly within them. Farmers' propensity and speed to accept new innovations are increased by the ease with which they can be tested to validate their benefits, and this may depend on how easily they can be tested for little or no expense (Yigezu *et al*., 2018).

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1: Summary

In the research region, it was noted that the availability of extension services, the cost of seedlings, the ability to purchase land, access to financing, household size, access to extension services and the availability of farm inputs all had a major impact on the uptake of tissue culture bananas in Kisii County.

The use of banana tissue culture was found to be significantly impacted by the farmers' low level of awareness on the subject. It was noted that non-adopters of the technology had low knowledge level on the technology hence low adoption as compared to adopters who were found to possess high knowledge levels on the technology hence high adoption. Most farmers were conscious of the advantages of tissue-cultured bananas, but they were constrained by socioeconomic issues that prevented them from implementing the technology. Small-scale banana growers who used tissue culture techniques to determine the advantages noted the following advantages: enhanced yields, with farmers able to harvest 30–40 tons per hectare, or twice as much as they could with older types. Additionally, respondents agreed that tissue-cultured bananas develop in 300 days as opposed to ordinary bananas, which require 400 days.

Farmers found that tissue culture bananas provided higher yields than native species when orchards were managed well. An apparent rise in output suggests that farmers could be able to sell more, generating more cash. This quality resulted from their quicker growth and special characteristics of being disease-free. plants with disease and insect resistance are yet another standout benefit that resulted from the investigation into the use of tissue culture. The participants in the survey agreed that proper orchard management not only results in higher yields but also keeps banana plants healthy and free of pests and diseases. The study also showed that bananas grown in tissue culture have a shorter growth cycle. KARLO officers cited the fact that several tissue culture plantlets could be grown quickly and would mature quickly as evidence. In summary, the aforementioned advantages support the promotion of food security. As a result, there was a strong correlation between the use of tissue culture bananas and their benefits.

5.2: Conclusion

Social and economic factors have a significant influence on people's adoption of tissue culture, and banana engineering. It is well known that farmers' social traits significantly influence whether they employ banana tissue culture technology or not. The cost of seedlings, access to extension services, availability of labour, the ability to buy land, the availability of funding, household size and the cost of agricultural inputs all have a big influence on the technology of tissue culture banana adoption.

Farmers' low level of knowledge on tissue culture bananas has a significant impact on the adoption of the technology. Implementing and maintaining the technology is simple for farmers who are familiar with tissue culture methods for producing bananas. Based on the advantages highlighted by farmers who have used it, this study concludes that, despite its high implementation costs, tissue culture banana technology has more benefits than drawbacks. Increased income generation as opposed to reliance on the typical banana suckers is one of the key benefits. Other notable benefits include increased output that is boosted by a harvestable bunch of bananas and boosted food security in between cereal harvesting seasons.

5.3: Recommendations

Based on the study's findings, the following proposals were made:

i. Supporting the formation of cooperatives for lending and savings among banana growers. They will be able to promote and provide financing to fund tissue culture banana cultivation by working with the right local financial institutions (the purchase of agricultural inputs and labor).
ii. Enhancing the agricultural extension services that are offered to farmers in rural areas in terms of research and development. Extension agents should be proactive in teaching farmers about sustainable farming practices.
iii. The county government has to figure out ways to lower the pricey tissue-cultured banana plantlets so that farmers will use them. Lowering the cost of the enhanced tissue culture of banana plantlets is equally important for encouraging their adoption.

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APPENDIX I: Questionnaire for Farmers

Tick where applicable Date……………….

Section A. General Information

1. Name of household/respondent: ________________________

2. Residence

   Location: _________________

   Village: _________________

   Division: __________________

   Sub-Location: _____________

   Sub-County: ____________________

3. Gender of respondents

   Male ☐ Female ☐

4. Age of respondents

   1 up to 25 ☐ 2 26-35 ☐

   3 36-45 ☐ 4 46-55 ☐

   5 56-65 ☐ 6 Above 65 ☐

5. Marital Status;

   Widowed ☐

   Married ☐

   Widower ☐

   Single ☐

   Separated ☐

6. Household head occupation

   1 Farming ☐

   2 Employed ☐

   3 Business ☐

7. Food crops cultivated?

   Maize ☐ Beans ☐ Bananas ☐

   Other (specify) ______________________________________

8. Labour availability

   1 Family ☐

   2 Hired ☐

   3 Hired and Family ☐

9. Land ownership:

Freehold land ☐ Family land ☐

Bought ☐ Rent ☐

Inherited ☐

10. Household size……………………………..
11. Access to credit 0 Yes ☐ 1 No ☐
12. Farm input 0 Yes ☐ 1 No ☐
13. Extension services 0 Yes ☐ 1 No ☐
14. Availability of seedlings 0 Yes ☐ 1 No ☐
15. Affordability of seedlings 0 Yes ☐ 1 No ☐

Section C. Technology Dissemination

1. Have you ever attended a tissue culture 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

   ____

2. Is the process of notification satisfactory to you?

   Yes ☐ No ☐

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

   Yes ☐ No ☐

   If yes, what did you learn? ______________________________________

4. What variety of bananas do you plant?

   i. ____

   ii. ____

i. ____

5. After exposure, did you decide to adopt the technology?

   Yes ☐ No ☐

6. How are you involved in the tissue culture banana technology adoption process?

………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………

Section D: Socio-Economic

7. Indicate who makes each of the following decisions.

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

8. 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					
Labor at the household					
Risk avoidance mechanism					
Lack of TC seedlings					
Poor agricultural extension services					
Climatic constraints.					

Other.; Specify...………………………………………………………………………………

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

   i. ____

   ii. ____

10. What are the Benefits of TC banana technology adoption?

Benefits	**SA**	**A**	**N**	**D**	**SD**
Increased yield					
More income generating					
Pest and Disease resistant					
Short Growth period					
Promotes food security					

Section E: Additional information.

Please indicate if you **SA-**strongly agree, **A-** agree, **N-** not sure, **D-** disagree, or **SD-** strongly disagree with these statements about your knowledge of tissue-cultured banana production processes. (Tick where appropriate)

Tissue culture banana production strategies.	**SA**	**A**	**N**	**D**	**SD**
It's necessary to top-dress my plant with 100g of C.A.N fertilizer or Urea every month beginning 3 months after planting.					
C.A.N or Urea should be applied in a band 2ft. away from the plant and covered with the soil.					
It is acknowledged that 50% of tissue cultured					

banana production increase can be attributed to efficient fertilizer use when other factors remain constant.					
Appropriate combinations of organic and mineral fertilizers may be the best way of affecting soil fertility to boost banana production.					
The ratio of combining mineral and organic fertilizer should be 1:1 or 50/50.					
Spacing banana plants during planting is important to reduce competition for water and nutrients during growth.					
It is recommended to plant a banana plant with a 2.5 x 2.5m or 3m x 3m inter plant spacing with the depth being 3 x 3ft.					
Topsoil should be mixed with manure and fertilizer in the ratio of 1-2 debes of manure per hole and 100g DAP.					
There is a need to de-leaf; the hygienic removal of banana leaves that are infected with the black-leaf-streak disease (black Sigatoka)					
The common farmer practice of using suckers increases the risk of banana diseases and pests infection-causing yield loss					
Tissue culture banana is one successful technology that is pest-and-disease free					
Tissue culture banana mature early and uniformly thus creating good market opportunities					

What is the average maturity age for tissue-cultured banana?**......................................**

APPENDIX II: Interview Schedule for Agricultural Extension Officers.

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: **A - 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**

Constraints	**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 tradition.					
Climate.					

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

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

APPENDIX III: Interview Schedule for KARLO 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			

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

____

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

____

6. Do farmers visit your offices of professional advice 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. ____

APPENDIX IV: 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 V: Approval of Research Proposal Letter

KENYATTA UNIVERSITY
OFFICE OF THE EXECUTIVE DEAN GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke
P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Executive Dean, Graduate School **DATE:** 11th July 2023

TO: Mr. Erick Nyaboga Omari **REF:** N50/28441/2019
C/O Department of Environmental Sciences and Education

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

===

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 22nd May, 2023.

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

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking and Progress Report Forms per semester. The forms are available at the University's Website under Graduate School webpage downloads.

Also, please ensure that you publish article(s) from your thesis before submitting it to Graduate School for examination as per the Commission for University Education and Kenyatta University guidelines.

Thank you.

REUBEN MURIUKI
FOR: EXECUTIVE DEAN, GRADUATE SCHOOL

cc. Chairman, Department of Environmental Sciences and Education

Supervisors:

1 Prof. Monicah Mucheru- Maina
C/o Department of Environmental Sciences and Education
Kenyatta University

2 Dr. Benson Kamau Mburu
C/o Department of Environmental Sciences and Education
Kenyatta University

APPENDIX VI: Copy of Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **105446**

Date of Issue: **20/December/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Erick Nyaboga Omari of Kenyatta University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kisii on the topic: Factors Influencing the Adoption of Tissue Culture Banana Technology in Kisii County, Kenya for the period ending : 20/December/2024.

License No: **NACOSTI/P/23/31795**

105446

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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See overleaf for conditions