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Socioeconomic factors influencing the uptake of tissue culture banana technology in Kisii County, Kenya

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ABSTRACT

Many nations have worked hard over the years to provide food security for there entire country, albeit with various degrees of success. The intensification of agriculture has been significant in order to feed the growing population. The banana tissue culture technology is one of the technologies used to aid the process of agricultural intensification. Due to its long history of food production, including the cultivation of bananas, the Kisii region is a significant contributor to Kenya's food security. However, because of issues brought on by social and economic considerations, the region's food output has been declining. Despite efforts to distribute this technology to small-scale farmers, majority of research studies in Kisii County show poor rates of technology adoption. The objective of this study was to examine the socioeconomic factors affecting implementing tissue culture bananas in Kisii County. The research used a descriptive study design. Two hundred respondents were chosen at random from the sample to participate in the study. Survey forms, interview schedules, and observation checklists were used for data collection. The means between adoption categories were declared at $p < 0.05$ in *t*-tests between tissue culture banana adoption and numerical factors. Chi-square tests were performed between adoption and categorical factors, and $p < 0.05$ was used to determine whether there were significant connections between the variables. The study adopted a logistic regression model with maximum likelihood estimation to calculate the likelihood that farmers will adopt tissue culture bananas as impacted by various socioeconomic factors. Results showed that the availability of extension services ($p = 0.000$), cost of seedlings ($p = 0.000$, x^2=79.1), ability to purchase land ($p = 0.006$, x^2=16.3), access to financing ($p = 0.007$, x^2=7.468), education level ($p = 0.015$), ability to afford seedlings ($p = 0.000$, x^2=17.6), labour availability ($p = 0.005$, x^2=10.735), availability of farm inputs ($p = 0.000$, x^2=35.9) and the size of household ($p = 0.05$, Std=1.8) were significant to tissue culture banana adoption. Socio-economic factors ought to be taken into account in order to assist a number of stakeholders in boosting banana output and enhancing food security.

Introduction

Despite the fact that there is arguably enough food in the globe to feed everyone, food distribution and availability are not limited by geography or time. The average dietary need for energy is 2881 kcal/person/day, however normal diets worldwide provide 2353 kcal/person/day (FAO 2014). Food shortages occur periodically in regions due to a variety of factors, including unfavorable conditions for food production, environmental degradation, labour or supply chain disruptions caused by extreme weather, economic crises, conflicts or insecurity, sanctions, and health shocks like epidemics. These factors can occur at both the macro and micro levels (G. N. A. F. Crises and others 2021). This makes us to worry on, what happens, though, if food production declines, food reserves are extensively depleted, or global trade declines as a result of an increase in protectionist policies? Although such a scenario is rare, it might have serious effects on the food supply in nations that rely on food imports and exacerbate the situation in nations where there are already acute food shortages (Udmale et al., 2020). One of the key elements of food balance is international trade as part of supply chains or distribution; if this is impacted by a global shock, it could have detrimental effects on food security that endure a long time (FAO 2017).

Over 20% of the 840 million hungry people globally, or 98 million Africans, are affected by the world's worst problem: hunger (KARI,

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2006). Given that agriculture employs a sizable portion of the population in many sub-saharan African (SSA) nations and is the main source of income for rural communities (Panel et al., 2011), over 10 million Kenyans, or roughly 25% of the population, still do not have access to enough food in sufficient quantities and of sufficient quality, therefore they rely mostly on food aid at any given time of the year (Sibhatu et al., 2015). This inaccessibility to food is closely tied to loss of aid and a rise in poverty rates (W. B. Group 2018). Unicef, W. H. (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 those living below the food poverty line. According to estimates from the Global Report on Food Crises, over a ten-year period, the number of people in Kenya facing food insecurity substantially increased, going from 1.3 million in 2007 to 2.2 million in 2017 (Unicef, W. H., 2017). According to the Sustainable Development Goals, Kenya and other Sub-Saharan African countries need to implement the right agricultural interventions to address issues of hunger and poverty and keep up with the world's expanding population (Kentikelenis et al., 2016). This implies that emerging nations like Kenya with strong rates of population growth won't be able to meet their food demands in comparison to industrialized ones, unless a solution is found (Fischer and Qaim, 2012). Many people in developing countries are undernourished, thus it will be crucial to increase current food production levels to supply a growing population with an appropriate diet (Joosten et al., 2015). Experts regret that widely adopted green revolution technologies no longer provide breakthroughs in yield potential or remedies for difficult insect, disease, and drought stress issues; as a result, the future production issue won't be addressed by agricultural technology in its current state, necessitating the development of new methods to increase food production (Karembu et al., 2010). Sens' entitlement theory holds that socioeconomic issues and distributional dynamics, not issues with food availability, are what cause famines (Rubin, 2016).

Banana, a member of the *Musaceae* family of plants, meets more than 25% of the world's carbohydrate needs (Njue, 2015). Bananas are cultivated on more than four million hectares of land worldwide, yielding more than 70 million tons of fruit each year (Pappu et al., 2015). The banana ranks fourth among food crops in the majority of developing countries, trailing only rice, wheat, and maize; as a result, it is a significant employer and a source of both on- and off-farm income in important industrial settings, so it is imperative to emphasize its intensification in order to ensure food security (Tumuhimbise and Talengera, 2018). However, banana is the third-most important starchy staple food, behind sweet potato and cassav (FAOSTAT 2018). Smallholder farmers, the most of whom are rural women in Kenya, cultivate and harvest bananas (Paul et al., 2018) and contributes to about 32% of the total fruits export revenue earned abroad (Directorate, 2016). Most bananas were farmed in the Western, Central, and Central Eastern regions (Thuo, 2018). These areas have a high potential for banana production due to their good agro-ecological conditions, which greatly support the growth of banana crops. Bananas are mainly consumed domestically and make up about 25% of all calories consumed, with an annual per capita intake of 220–460 (FAOSTAT 2018). One of the most often advocated agricultural methods is banana tissue culture, yet adoption rates in Kenya are only around 7% and significantly lower in Uganda and Burundi (Warinda *et al.*, 2020). Despite the crop's importance and the existence of favorable growing regions, Kenya has been experiencing low banana output due to poor agronomic practices and insufficient access to clean and affordable planting supplies (Wahome et al., 2021). According to Wahome et al. (2021), the two main factors affecting banana productivity are the use of superior planting materials, effective application of fertilizers, mulch, and manure, as well as labour. The adoption of tissue cultured bananas has been shown to increase yields, but a recent impact assessment for Kenya also highlighted the importance of efficient plantation management and growth (Murongo et al., 2022). Wahome et al. (2021) observed that there was potential to enhance banana production in the research counties, but it was difficult due to poor public awareness and a lack of available inputs in the three study locations. The Kenyan farmers face an additional adoption challenge as a result of this additional requirement and the relatively high cost of tissue culture banana plantlets (US$ 1.20 to 2.00) since in order to maximize their benefits, tissue culture banana plantlets need to be handled and managed properly (Wahome et al., 2021). Additional suggested techniques, such as weeding, irrigation, desuckering, deleafing, and debudding and social economic factors should be prioritized enough to help farmers achieve steady output levels (Warinda et al., 2020).

The adoption of banana tissue culture technology, like other cutting-edge technologies, has the benefit of expanding food access, generating income through the sale of product, raising tax revenue, and creating jobs for women and young people (Wambugu et al., 2008). However, what needs to be done to make future progress more effective and how far have researchers actually come in terms of supplying small-scale farmers with the knowledge, resources, and supplies required to engage in tissue culture banana cultivation (Woomer, 2012; Wahome et al. 2021) noted that research must be promoted to try and address these gaps given the limits in knowledge, uptake, and utilization of banana tissue culture methods. Lack of timely and accurate information access has been identified as a major impediment to the growth of Kenya's rural agriculture (Adolwa et al., 2010), hence tissue culture banana technologies are impossible to develop, especially considering how uninformed end users and household characteristics are. Additionally, there are gaps in the documentation of the kinds of information that smallholder farmers have (Obala, 2013). In order to improve tissue culture banana adoption, increase its output, and lower the prevalence of food insecurity, it is necessary to conduct this research in order to identify the social and economic aspects that influence its adoption and use.

Review of literature on the acceptance of tissue culture bananas

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 external environment, and characteristics 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.

It's challenging to implement an innovation at the organizational or systemic level. When organizational decision-makers do not believe that changes are necessary, it is more difficult to impose changes on standard practice (Garland et al., 2010). Though there are parallels with private adoption, Aarons et al, (2011) noted that people working in organizations may find it difficult to comprehend, assess, or choose appropriate innovations to address particular issues, or that organizational factors (like hierarchy, culture, and values) often make it difficult to decide which innovation to adopt because they aren't always present when addressing issues at the individual level. Talukder and Quazi (2011) asserted that people's adoption of new ideas is significantly influenced by the views held by those in their social networks regarding innovations. Additionally, it has been observed that an individual's social network significantly influences how quickly they adopt new ideas.

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 attitudinal components or beliefs, 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 reflects the benefits a person believes that technology can offer to increasing their work performance (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.

Material and methods

Description of the study area

South-western, the former Nyanza Province is where the Kisii County of Kenya is located. There are 1266,860 residents in the county (KNBS 2019). The county has a total size of 1332.7 km^2 and is located between 00° 30′ and 01° 0′ South Latitude and 34° 38′ to 35° 0′ East Longitude (GoK 2018). Bogusero, which is a piece of Kisii, receives 1500 mm of rain annually, with the heaviest showers that fall 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. The soils from a red volcano, which are recognized for having a significant organic content, cover 75% of the ward (GOK 2019) with 24,872 inhabitants, a 32.70 km^2 area, and sub-divided into Bigege and Raganga sub-locations, to make the southern location and Matieko and Santa sub-locations, to make the northern location. Fig. 1 shows Bogusero ward, the limit between Homabay County and Kisii County, to the north in the subcounty of Kitutu Chache South.

Research design

The study used a descriptive study approach. Simple random sampling was used to select the study's respondents. Survey forms, interview schedules, pictures, and observation checklists were used in the data collection process via a carefully crafted and thoroughly validated questionnaire.

Questionnaire design

There were various sections in the questionnaire. The respondents were given a verbal explanation of informed consent in the first segment. The questionnaire was correctly completed once the respondents gave their approval. The questionnaire was filled up with the explanation of the question and the response. The next section comprised if the social economic aspects of the households that included; age, gender, marital status, education level, extension services, seedlings affordability, land acquisition, HH occupation, access to credit, labour availability, access to farm inputs, land size under banana in Ha, HH size and farming experience. The last section comprised of the other challenges faced by banana farmers and the possible recommendations to enhance tissue culture adoption.

Sampling procedure

The study employed simple random sampling to collect data from the respondents. In order to produce reliable data, an unequal sample size was randomly selected from each of the four nearly identical sub-locations that comprise Bogusero ward due to the farmers' poor distribution throughout them. Since KARLO and Agricultural Officers are widely known to possess extensive knowledge of the agricultural systems in the research area, a purposeful sampling strategy was used to recruit all of them at the ward level.

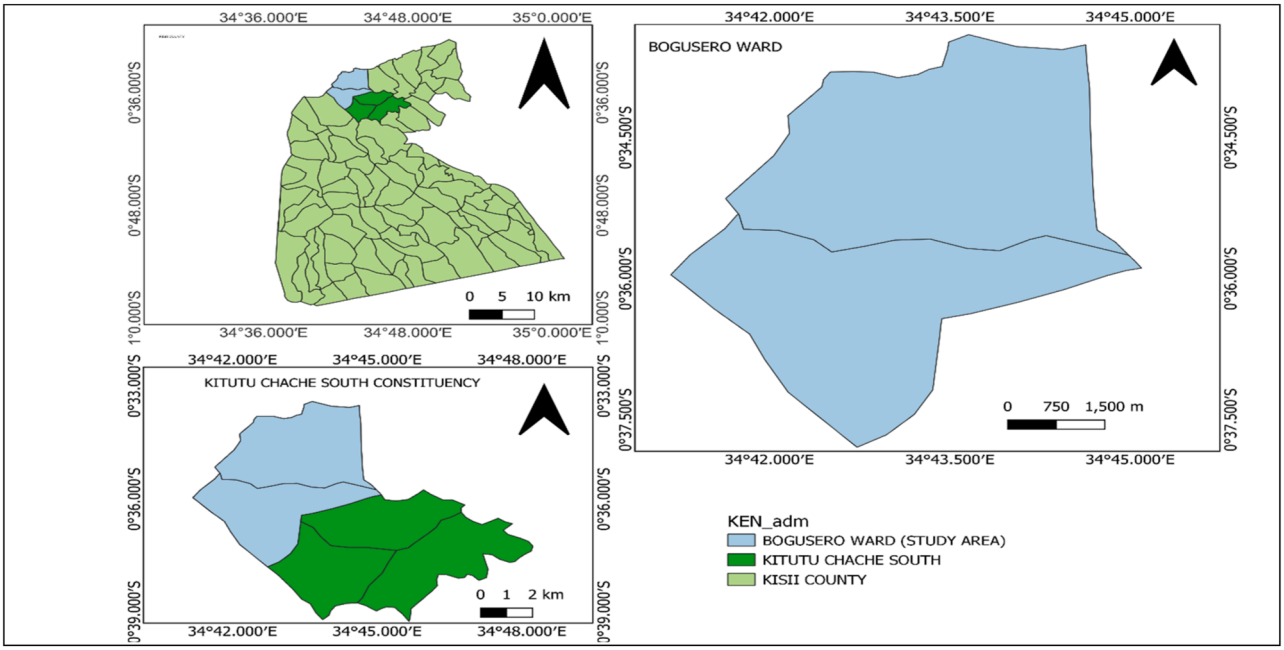

Fig. 1. Map of the study area. (Modified from Kenya administrative units).

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. $400/1 + 400 \times 0.05^2 = 200$.

Data analysis

Farm socio-economic characteristics were related to tissue culture banana adoption using comparative statistical procedures using SPSS procedures. T-tests were conducted between tissue culture banana adoption and numeric characteristics; means between adoption categories were declared at $p<0.05$. Chi-square tests were conducted between adoption and categorical variables and significant relationships between the variables were declared at $p<0.05$. Responses from qualitative data were evaluated and narratively presented.

Model specification

This study used a logistic regression model with maximum likelihood estimation to calculate the likelihood that farmers will adopt tissue culture bananas as impacted by various socioeconomic factors. The binary logistic regression was calculated using the statistical package for social sciences (SPSS) (Norusis, 2008). The "logit" represents the natural log odds of adopting tissue culture bananas. $Y = 1$ indicated whether tissue culture bananas were used in smallholder farms, and X represented a vector of explanatory socioeconomic variables, including age, marital status, occupation, labor, education, farming experience, farm size, credit access, and input access (Equation 1).

$$\begin{aligned} \text{logit}[p] &= \ln[\text{odds}(Y=1)] = \ln\left[\frac{p}{1-p}\right] \\ \text{logit}[p] &= \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_4\chi_4 + \beta_5\chi_5 + \ldots\ldots\beta_i\chi_i \end{aligned} \quad (1)$$

The binary regression model's feasibility was verified using a number of model tests. A large p value is preferable in the Hosmer and Lemeshow test of goodness of fit, which assessed how well the model fit the data. Nagelkerke's R^2 is an estimated coefficient of determination for models with categorical response variables that is comparable to the R^2 value in linear regression models. When independent variables are incorporated, the percentage accuracy in classification value measures the proportion of cases that can be accurately classified in a response category (Norusis, 2008). The following table shows the variable descriptions for the regression model. The response categories for categorical variables were re-classified into dummy and continuous variables as follows (Table 1).

Table 1
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 attainment of HH	1=More than primary, 0= below primary	Dummy
Farming experience	Length of farming	Years	Continuous
Farm size	Total farm size of the 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

Results and discussions

Socioeconomic aspects affecting acceptance of bananas grown by tissue culture in kisii county

Household socio-economic characteristics of respondents of bogusero ward

The study found that 18 out of the 200 families investigated, or 9% of the total, had embraced tissue-cultured bananas, indicating a comparatively low adoption rate. This clearly demonstrates that, despite its benefits, the technology has not been embraced by the majority of farmers. This is consistent with earlier research by Wahome et al. (2021) who noted that the truth was that there was a generally low acceptance rate of this technology, despite any potential advantages of methods for banana tissue culture, such as the speedy generation of a substantial volume of disease-free planting materials in the Embu, Kisii, and Nyamira counties. Similarly, Muthee et al. (2019) noted that just 27.8% of the farmers in Embu County who were studied had started using tissue culture planting materials. Thuo (2018) also found that tissue culture banana adoption was low in the Kalawa, Kithimani, and Thaana regions of Kenya's Lower Eastern Semi-Arid region. Chrismanto et al. (2019) noted that technical development is essential to the future of the agricultural sector. Innovation in the industry supports the growth of the farm sector and the increase in industry production (Lavoie et al., 2021). The agriculture sector's traditional operating processes have evolved as a result of technology since better machinery enables the sector to function in innovative ways (Xu et al., 2021). The greatest impact on the expansion of the economy through agricultural products is made by farmers who creatively promote the agriculture industry (Kant and Shahid, 2022). The dissemination of technology is unquestionably essential for growing the agriculture industry in every country because the adoption of new techniques occurs gradually (Stephens et al., 2018). Compared to conventional innovators who do not employ technology, agricultural technology innovators fare better (Sapbamrer et al., 2022. Xu et al. (2021) noted that research from the agricultural performance sector demonstrates that less productive farmers are resistant to innovation. The agricultural industry is considered vital for technology because it helps the economy's innovative growth (Jung et al., 2021). As a result, it was noted that implementing new technology in a way that is in line with farmer thinking benefits farmers (Stephens et al., 2018). It is hoped that increased farm output level supported by the use of technology in smallholder agriculture will result in the urgently required transformation of the agricultural industry (Bachewe et al., 2018).

Banana cultivation took place for an average of 9.1 years (Std=4.7), compared to 3.6 years for adopters. Banana farms ranged in size from 1 to 6 ha, with an average size of 2.6 ha (Std=1.3). According to FAO (2022), this indicates that they were small-scale cultivators. As opposed to growing different crops on separate stands, all farmers were seen to engage in mixed farming, which involves growing crops including napper grass, maize, cassava, beans, onions, kale, sweet potatoes, and others alongside bananas. Due to the clusters' high population density and the fact that the majority of the locals were small-scale farmers, this resulted. The primary cause of the tiny areas of land utilized for banana growing was increased population among the primary inheritors of their parents' land. The average number of residents per family was 5.5 (SD = 2.0) (Table 2). Non-adopters' average household size (5.6) was much larger than that of adopters (1.8). According to the study, the majority of banana producers, or 37.5% of the respondents, were between the ages of 36 and 45. This was related to the fact that at this age, adults depend more on their property and judgment than they do as children, who are only partially dependent. The youth (26–35 years old) were close behind with 31.5%, which can be attributed to the fact that this is the stage of transition from independence to reliance. The span of up to 25 years reflects a low proportion at this stage because of the heavy reliance on

Table 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

the household head. Due to the low level of farming activity—2.5% in this case—older individuals over 65 tend to depend on their children. The majority of farmers who were non-adopters belonged to the 26–45 age group, which made up 69% of all farmers. According to the age and adoption argument, the majority of adopters (44.4% of all adopters) were between the ages of 26 and 35 (Table 2). The new technology seemed to be met with resistance from the elderly.

According to the findings, 60.5% of banana farmers were men and 39.5% were women. In contrast to their female counterparts, who made up 40.7% of the total, men made up 59.3% of the non-adopters. Comparing adoption by gender revealed that, at 72% of adopters, men constituted the majority. This resulted from the fact that in an African environment, the majority of homes are headed by men who are involved in significant ways in family decision-making. They have more influence over how the land is used because they are its proprietors.

Women have the right to use the land and handle most of the household and agricultural tasks. Results showed that 88.9% of banana growers who had used tissue culture and 87.4% of all banana growers were married. Achieng (2017) noted that since they had more labour than couples with only one spouse working full-time on the farm had, couples with both spouses working full-time on the farm had a higher possibility of adopting intensive soil fertility management technologies. The majority of banana growers in the research region were college graduates, with a 53% completion rate, followed by a 45% completion rate for secondary school (Table 2). Majority (54.9%) of non-adopters had finished their university education, while 43.4% had finished their secondary school. The majority of adopters (61.1% of the total) had a good level of understanding and had finished secondary school, while 33.3% had acquired tertiary education (Table 2). This revealed that a large portion of the educated population in the region worked in local banana growing.

The results showed that 80% of farmers were unable to access expanded services. 87.9% of those who did not adopt had no access to extension services. It was because there weren't as many extension officers in the region. There was access to extension assistance for all farmers who had adopted the tissue culture banana technique (Table 2). The reason for this was that they were easily able to get in touch with them because they had acquired the seedlings from the county government via the extension authorities. The majority of respondents in the study—74.5% of all respondents and 78.6% of non-adopters—reported having a negative impression of being able to purchase seedlings (Table 2). The majority of them did not have access to loans as a majority of them lived very close to the poverty line, which was cited as the reason for this. Majority (66.7%) of people who had already accepted technology said they would be able to purchase the seedlings if they were supplied. This was due to the fact that the majority of them could obtain loans since, aside from banana growing, they engaged in income-generating activities that provided them with collateral for loans. However, it was noticed that access to the seedlings was a concern, which was attributed to the absence of a verified source of tissue seedlings in the region and its environs. According to the survey, 83.3% of adopters, 98.9% of non-adopters, and 97.5% of all banana producers obtained their land through inheritance. This resulted from the old way of life, which involved inheriting land from the parents. Because this area was so easily accessible, there was less need to lease land.

Farmers made up the majority of household heads (45.5%) and non-adopters (46.7%), compared to workers (38.1%) who adopted (Table 2). The bulk of the Kisii community relied on farming as a source of income, which accounts for its supremacy. According to the survey, 66.7% of adopters had access to financing, compared to 63% of all farmers and 65.9% of non-adopters (Table 2). Resources are needed for banana uptake and improvement in the deployment of agricultural innovations; however, this was hampered by a lack of financial resources. This was attributed to the fact that commercial banks turned away small-scale farmers seeking loans because they had no adequate collateral or repayment ability. Banana producers noted that farmers had a tendency to adopt new agricultural innovations as long as they had access to funding that would enable them to pay for labour, farm supplies, and other resources required for putting new technologies to work improving banana production. According to the survey, family and hired labour were used by 61.1% of adopters, 54.9% of non-adopters, and 55.5% of all farmers (Table 2). Some families preferred to hire labour from outside the family in order to continue with their formal obligations because there were fewer family members and other responsibilities, such as jobs. Additionally, respondents noted that they were hesitant to use tissue culture bananas due to the aggressive labour-demand tactics used in banana farming. The findings revealed that only 94.4% of adopters had access to farm inputs, whereas 76.4% of non-adopters and 70% of all farmers did not (Table 2). Due to their lack of access to resources that would have allowed them to buy farm inputs and their inability to afford security for loans, most farmers were blamed for this limited access.

Social economic factors influencing tissue culture banana adoption in Kisii county

Several factors affect the uptake of new technology by smallholder

farmers all over the world (Jha et al., 2019). This is due to the fact that smallholder farmers must learn new technologies and practices as well as how to integrate them into current systems (Salami et al., 2010). This study indicated that household size significantly influenced the adoption of banana tissue culture in the study area, with a p-value of 0.05 (Std=1.8) indicating that the larger the family, the more likely the adoption due to an increase in labour costs (Table 3). In the study by Wanyama et al. (2016), family size was found to be both a positive and significant factor suggesting that adoption of tissue-culture bananas is more likely to rise with family size increase. In the research by Claessens et al. (2012), smallholder farmer's household size was found to be a good indicator for both labour availability and financial commitment.

A p-value of 0.000 (x^2 = 79.1) indicates a significant correlation between adoption rates of banana tissue culture and access to extension services in the research area. Because they may learn more about cultivating bananas in tissue culture, farmers who receive more extension services are more likely to adopt the method. For distributing information about better practices and encouraging the adoption of these technologies, an efficient extension system is necessary (Kirimi et al., 2023). Adejuwon (2019) and Oyinbo et al. (2019) noted that when extension services were accessible to them, smallholder farmers embraced new technology more quickly because the specialists in extension aided in educating small-scale farmers about new technologies and their advantages, hastening their adoption of technology. The results by Sarker (2016) noted that a good extension system is essential for the dissemination of information about better practices and a quicker uptake of these technologies. Wahome et al. (2021) observed that lack of access to agricultural services, such as communication with extension agents or workers, was one of the reasons for the low production.

The adoption of tissue culture bananas and the price of seedlings in the study area were significantly associated, p=0.000 (x^2=17.6). This was a sign that more people are likely to adopt the technology, which would reduce the expenses incurred throughout the production process because they will be able to afford it. Michalscheck et al. (2018) and Akrofi et al. (2019) noted that agricultural technologies' high costs frequently limit their deployment. Consequently, Senyolo et al. (2018) observed that smallholder farmers in Africa have a tendency to avoid investing in and maintaining expensive technologies. According to elements of technology that were found to effect adoption, smallholder farmers were seen to accept new technologies depending on how simple they are to use in terms of needs of the body and mind (Smale and Mason, 2014).

Land acquisition in the research area was substantially connected with the use of tissue culture bananas (p=0.006 (x^2 = 16.3)) (Table 3).

Table 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.

This study shows that use of the technology rises when land ownership changes from acquired to inherited. This was attributed to the fact that inherited land is free of rent hence reducing the cost of production of banana tissue culture as a result of money paid for access to farms. A farmer is more likely to implement banana tissue culture technique if credit is readily available, as shown by the finding that availability to credit is crucial for adoption in the research area (p=0.007 (x^2=7.468). The study's findings are consistent with those of Sharma et al. (1997) who concluded that a household's ability to obtain credit facilities was more closely connected with its capacity to tolerate risks. Similarly, Nyang'au (2019) noted that some farmers lacked the financial means to implement banana tissue culture technologies. In the 128 publications that were looked at, 81 noted finance as a factor that influenced the uptake of new technologies according to Fadeyi et al. (2022). Studies have shown a substantial correlation between finances and African smallholder farmers embracing technology due to the majority of these technologies' high prices of both purchase and maintenance (Habtemariam et al., 2019). It has been demonstrated that financial assistance enables smallholder farmers to purchase, use, and maintain innovative technologies (Fisher and Carr, 2015). Smallholder farmers can also use loans to cover payroll, purchase farmland, and acquire the required training and expertise. Smallholder farmers will find it simpler to adopt new technology as a result. Smallholder farmers have been found to depend on financing not only to adopt new technology but also to research backup plans in the event that the new technology fails (Oyinbo et al., 2019).

The adoption of banana tissue culture in the study area was found to be significantly influenced by labour availability, p=0.005 (x^2 = 10.735). This showed that since banana production often requires a lot of labour in agricultural operations, increasing the labour force enhances the likelihood of adopting the technology. Findings of Nyang'au (2019) study noted that the farmers' adoption of strategies for banana enhancement had been hampered by a lack of labour-related human resources. The use of tissue culture bananas in the study area was found to be significantly influenced by access to farm inputs, p=0.000 (x^2 = 35.9). With access to farm inputs, a farmer is more likely to embrace tissue culture technology. Farmers will be able to produce bananas of higher quality if they have access to farm inputs, which will lead to a higher rate of technology adoption since they can use the inputs that lead to higher-quality production. Access to improved seed is essential if adoption is to increase (Awotide et al., 2016). Care must be taken with banana tissue culture, necessitating the provision of the necessary quantities of agricultural inputs in order to increase productivity and encourage adoption.

According to the regression model of factors influencing adoption, the logistic regression model of tissue culture banana adoption correctly classified 93.8% of the cases and explained 52% (Nagelkerke R^2) of the variation in dependent variables (Table 4). The adoption of tissue culture bananas was found to be significantly influenced by accessibility to information and education. Compared to farmers with education levels below elementary school, those with education levels above that level

Table 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	12,981.01

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

were 0.002 times more likely to adopt tissue culture bananas. Additionally, compared to farmers without access to agricultural inputs, farmers with input access had a 0.018-times higher chance of implementing tissue culture banana technology. Compared to farmers with lower levels of education, farmers with greater levels of education are more likely to understand information, look for, and use more specialized or explicit knowledge. 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.

Conclusion

The acceptance of tissue culture and banana engineering is significantly influenced by social and economic factors. It is generally established that social characteristics of farmers have a substantial impact on whether they use or reject banana tissue culture technique. The adoption of tissue culture banana technology is greatly influenced by the price of seedlings, the ability to purchase land, the availability of funding, and the price of agricultural inputs. To help a variety of stakeholders increase banana adoption and subsequently improve tissue culture banana adoption and banana production, which will in turn stimulate an improvement in food security, it is necessary to establish savings and credit cooperatives and subsidize the price of tissue culture banana plantlets. Additionally, the Kenyan government and other interested parties should invest more in extension to strengthen the connection between the farmer and the researcher. To make it easier for farmers to acquire tissue culture plantlets, the government ought to set up a banana tissue culture nursery in each Bogusero ward sub-location. In order for farmers to adopt tissue-cultured banana plantlets, it must also find a solution to reduce their exorbitant cost. Encouraging the adoption of banana plantlets requires lowering the cost of their enhanced tissue culture. This would facilitate the spread of knowledge about agro-technology to nearby farming communities and customers. In order to make tissue culture banana plantlets more accessible to farmers, regional supply hubs must be established.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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