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ANALYSIS OF PRODUCTION, SOCIO-ECONOMIC AND INSTITUTIONAL FACTORS AFFECTING TECHNICAL EFFICIENCY OF SMALLHOLDER BANANA PRODUCERS IN KIRINYAGA CENTRAL SUB-COUNTY, KENYA

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ABSTRACT

Banana provides food, nutrition security and income for most households and is fourth most popular food crop in the world after wheat, maize and rice. Despite its significance, full potential of banana production in Kenya remains unexploited by smallholder farmers due to low technical efficiency especially in utilization of farming inputs due to production, socio-economic and institutional issues among others. In Kirinyaga County, the actual banana production is at 4-18 tonnes per acre against the potential of 30-40 tonnes. Despite the limited supply of resources for production, attainment of highest possible levels of technical efficiency is key to achieving sufficiency in banana farming. The study analyzed the effects of production, socio-economic and institutional factors on technical efficiency among smallholder banana producers in Kirinyaga Central Sub-County, Kenya. A cross-sectional research design was used. Questionnaire was administered randomly to 402 respondents selected using multi-stage sampling technique and data analyzed using Stata version 17 and SPSS version 25. Descriptive statistics described the production, socio-economic and institutional factors. A stochastic frontier analysis approach was used to model the efficiency levels using Cobb - Douglas functional form estimated using the maximum likelihood technique. The study showed that technical efficiency varied between 0.93% to 95.45% and average technical efficiency of 83.14%. The study found that manure and planting materials had positive effects on technical efficiency whereas land size had negative impact. The findings established that age of decision maker and size of the household had negative effects whereas education, experience, farmer group membership and market access had positive effects on technical efficiency. The study advises persons with high levels of education to get into banana farming because smallholder farmers with greater levels of education demonstrated high levels of production efficiency. Additionally, to improve efficiencies, farmer group development and membership are encouraged and also extension services made more accessible.

Key Words: Technical efficiency, Socioeconomic factors, institutional factors, smallholder banana

producer

INTRODUCTION

Banana (*Musa spp*) is a tropical crop produced in approximately 130 countries worldwide (Dhake *et al*., 2019). It is rated number four as a food crop among developing nations after wheat, maize and rice (Tumuhimbise and Talengera, 2018). In addition, banana production act as employment and income source to smallholder farmers in high production areas. Ninety-eight percent of whole world banana come from undeveloped nations (Pillay *et al*., 2012) and is one of the most consumed fruit and helps to meet both food and nutritional security for smallholder farmers. Banana is a high-value commercial fruit and highly demanded (Bhatta *et al*., 2023). It has become the most consumed and exported fruit in the world and is grown on smallholder farms and large plantations around the world (Voora *et al*., 2023). Fifty percent of all domestic horticulture production is contributed by banana production (World Bank, 2020). According to FAO (2022), more than 1000 varieties of banana exists in the world and Cavendish banana is the most popular type and merchandized.

More than 60% of the global banana production is from Brazil, China, Ecuador, India, Philippines, Indonesia (Vinayagamoorthi *et al*., 2019) and approximately land area of 5.6 million hectares are dedicated to its production (FAOSTAT, 2017). The world's largest banana grower is India, accounting for around 15% of the total worldwide area and 29% of the global overall output (Dhake *et al*., 2019). India produces an average of 39 million tonnes annually (Eutycus, 2019). Eighty percent of banana fruits produced globally are locally consumed and 20% are exported (Vinayagamoorthi *et al*., 2019). According to Voora *et al*. (2020), banana is among the most traded fruits in the world and in 2018 around 155 million tonnes were produced and traded (FAOSTAT, 2020). According to FAO (2022), several factors affected banana trade in 2021 including banana production shortages and the continued spread of banana plant diseases. In Africa, approximately 70 million people rely on banana to support their financial needs (Geberewold, 2019) and it has been reported being among the most significant food security crop for Africa's Central,

Eastern and Western regions (Obaga, 2018). Eastern and West Africa are some of the well-known banana growers in Africa with Uganda, Cameroon, Tanzania and Kenya producing the most (Olumba & Onunka, 2020). Further, about 2.3% of all worldwide total banana harvested is produced in West Africa. The top banana-producing nations in the West Africa region include Côte d'Ivoire, Liberia, Guinea and Mali. The world's biggest producer of highland bananas is Eastern Africa and it contributes around 20% to global banana production (FAO, 2020). The majority of Africa's bananas are produced in Uganda and most of the grown bananas are the cooking *Matooke* and the brewing *Mbidded* types (Arinaitwe *et al*., 2019).

In Kenya, banana production is mainly on small scale and aids in meeting the nation's food needs (Eutycus, 2019). In some regions of the country, minimal irrigation is done but the output is primarily rain-fed and has the potential to benefit the smallholder producers as well as other participants in the value chain (Karienye and Karimi, 2020). Common varieties grown include the cooking types: Uganda green, *Mutahato*, *Nusu Ng'ombe*, and *Gradi shisikame*, whereas among the dessert options include: apple banana (*Ndizi sukari*), *Bogoya*, *Bokoboko*, Chinese Cavendish, Gros Michel, giant Cavendish, *Kampala* and *Muraru* (Wahome *et al*., 2021). Additionally, in Kenya banana constitutes one among the most significant basic crops, accounting for 14% of the country's overall crop value and 20% of the total food consumption (Kirimi *et al*., 2021). Banana also accounts for around 32% of all fruits exported foreign earnings (Horticultural Crop Directorate, 2016). The ripe banana is among the fruits that city dwellers consume most, whereas plantains are the second most popular fruit across all socioeconomic levels (World Bank, 2020). Banana production is largely practiced in the Eastern, Western and Central areas (Omondi *et al*., 2020) and its output consumed locally (USAID, 2017). Meru, Kirinyaga, Muranga, Kisii, Tharaka Nithi, Kiambu, and Taita Taveta are the most productive counties, with a total production of 17%, 11%, 9%, 8%, 8%, and 5% respectively [Agriculture and Food Authority
(AFA, 2016)].

In Kirinyaga County, the major fruits grown in order of importance are banana 34.85%, Mango 20.13%, Pineapple 15.52%, avocado 9.90%, water melon 5.67% and Pawpaw 4.73%. Banana production in Kirinyaga County was estimated at 117,356 tonnes in 2017 and 152,409 tonnes in 2018 (KNBS, 2018). Banana farming is a popular choice

among farmers because of its adaptability for cultivation within the region, great market demand, and relatively simple management of the crop (Mbaka *et al*., 2008). A study by Kairu (2020) in Kirinyaga found maximum harvest of banana at 108,000 kgs and a minimum of 400 kgs and this translates to actual production of 4 -18 tonnes per acre against the potential of 30-40 tonnes per acre. Kairu (2020) further found that out of the 302 respondents, 153 indicated that their banana production remained the same, 210 respondents their area under banana cultivation ranged between
0.1 to 0.3 acres indicating that small pieces of land were allocated for cultivation of banana.

Several factors have an impact on banana production which cut across socio-demographic factors, agronomic and management practices (Wahome *et al*., 2021) and among them are diseases, subpar agronomic techniques, pests, and a lack of access to clean and reasonably priced suckers. Lack of provision and accessibility to extension services and proper plantation management, marketing and climatic factors also affect banana production (Murongo *et al*., 2018; Adhikari *et al*., 2022). Karienye and Karimi, (2020) also noted that land use changes, fluctuating labour costs and soil water retention affects banana production. Despite the challenges, banana production is an economic revenue source with a strong potential for profit for a nation thus a rise in its levels of production efficiency would lead to a society that is nourished and secure in its food supply and a positive influence on rural growth (MOA, 2017). Given that there is a huge demand for banana fruits especially in towns (World Bank, 2020; MOA, 2017), a country's food supply would increase and producers would receive more money if production efficiency were to increase. An increase in banana output would result in more job prospects, more revenue, and better food security. This is crucial to achieving Kenya Vision 2030 as well as achievement of the Big Four Agenda by the national government as well as the sustainable development goals. Comparing farmer performance and locating the causes of inefficiencies in production is made easier with the use of technical efficiency measurements (Kassa and Demissie, 2019). To assess technical efficiency, it is crucial to consider a farmer's performance and the variables that influence efficiency (Dessale 2019). As a result of inefficiencies in production there is a necessity to investigate technical efficiencies in agricultural production, especially among smallholder banana producers.

MATERIALS AND METHODS

The study was carried out between December 2022 and February 2023 in Kirinyaga Central Sub County, Kirinyaga County within Mt. Kenya region (Figure 1).

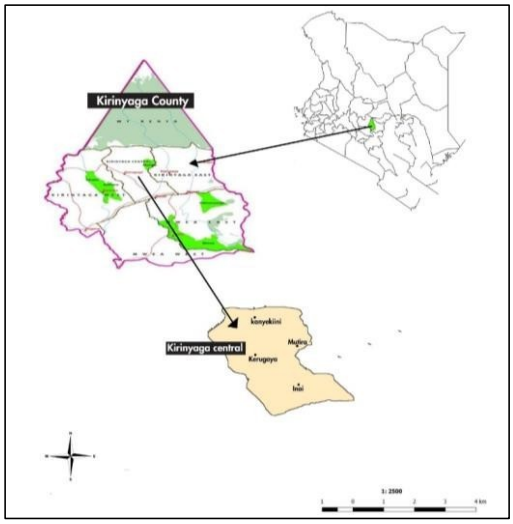

Figure 1: Map of study Area

Source: Geocurrent (2016)

Kirinyaga County is bordered to the north and west by Nyeri County, to the west by Murang'a County, and to the east and south by Embu County (County Government of Kirinyaga, 2020). The County covers a total surface area of about 1,478.1 kilometer squared. Kirinyaga Central Sub County is amongst the five sub counties in Kirinyaga County. The Sub County's overall land area is approximately 173.6 square kilometers and a population of 122,740 (County Government of Kirinyaga, 2020). The Sub County is organized into four wards: Mutira, Kanyekiini, Kerugoya and Inoi. The research area experiences bimodal rainfall, having prolonged precipitation through March until May and short rainfall throughout October into December, with amounts varying from 1,212 mm to 2,146 mm (GoK, 2018). The range of temperatures is 8.1 °C to 30.3 °C on average. Agricultural production is the major source of earning, and most of the farmers (70%) are smallholders (MOA, 2011). In addition, 87% of the county's population relies on it for their primary source of earnings, making it the most significant activity. Agriculture accounts for 72% of the incomes received by households and banana is among the major crops grown (County government of Kirinyaga, 2019).

The sample size of this study was 402 smallholder banana producers, Daniel and Cross (2013) formula was used to determine the sample size

$$n = \frac{[N z^2 p(1-p)]}{[(N-1)\ d^2+z^2 p(1-p)]}$$

where *n* is the sample size and *N* is the size of the entire population, *z* is equal to 1.96 which is the tabulated *Z* value for 95% confidence level, *p* is the approximate percentage of population included (50%) and *d* equals to the error limit (5%)

This study used a cross sectional research approach, that guarantees accuracy as well as calculates the percentage of a population's sample outcome that is actually realized (Bhattarai *et al*., 2016; Okonya and Kroschel, 2015). The design made it possible to collect quantitative statistics on inputs as well as outputs in one period in the production year 2022. The research approach enabled an assessment production, socioeconomic and institutional factors that characterize smallholder banana producers at a certain moment (Levin, 2006). The study adopted a multistage sampling technique in sampling banana producers. In the first stage Kirinyaga Central Sub-County had been selected from the five Sub-Counties and four wards purposively selected from the Sub-County. Secondly, within each of these chosen wards, farmers were selected randomly. Respondents in the study were chosen using simple random sampling from the wards.

D.ata analysis was performed after collection of data and coding. Descriptive statistics, such as standard deviations, frequencies, percentages and means were utilized to present and summarize data collected from smallholder banana producers who participated in the interviews. The data was then examined using Statistical Packages for Social Sciences (SPSS) version 25 and Stata version 17 was used as a computerized data analysis package for detailed findings on the study variables. SPSS carried out frequency analysis and descriptive statistics. The maximum likelihood estimation technique was used to estimate the stochastic production function based on the Cobb Douglas functional form. The projected efficiency ratings were further modelled against the chosen production, socio- economic and institutional factors using Stochastic model to find out the factors that affects technical efficiency.

Empirical estimation techniques: In the context of the Cobb-Douglas production function, this study employed the stochastic frontier model in identifying the production variables. The stochastic frontier model was defined in accordance with the models of Battese (1992) and Coelli (1995) as below:

$$Y_i = f\,(X_i; \beta)\ \exp\,(V_i - \cup_i)\text{...}(i)$$

where i = 1, 2… 402 farmer, Y_i is banana yield of 402 producer, X_i is a vector of the quantities of farm inputs used in banana production, $f\,(X_i\ ;\ \beta)$ is an appropriate Cobb Douglas production function. Under the assumption that $(X_i\ ;\ \beta)$ utilizes the log linear Cobb-Douglas form equation, then equation (v) can be expressed as;

$$lnY_i = \beta_0 + \beta_i lnX_i + V_i - \cup_i \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .\ (ii)$$

β*'s* are parameters, V_i is the random error that has a mean of zero and is related to uncontrolled variables like measurement error and climatic conditions that are beyond of the control of producers. $\cup_i$ is the inefficiency which is sometimes called the one-sided error term. The following was the specification of the Cobb Douglas production function for the banana growers in the study area:

$$lnY_i = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + V_i - \cup_i \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (iii)$$

where, ln = is the natural logarithm, $X1$ is labour used (Man-days), $X2$ is manure quantity (wheelbarrow), $X3$ is land size under banana production (acre), $X4$ is planting materials (suckers), $Y1$= total Quantity of banana (kg), βi= Parameter to be estimated, $V1$= are random variables which are assumed to be independent of U identical and normally distributed with zero mean and constant variance N $(0, \delta_v^2)$, U= it represents production technical efficiency.

Technical efficiency of the banana farmers is defined to be the ratio of observed output (Y_i) to the corresponding frontier output (Y_i^*) using the existing technology and so the technical efficiency of the farmers is denoted by;

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{exp(\beta X_i + V_i - \cup_i)}{exp(\beta X_i + V_i)} = exp(-\cup_i) \text{..................................} (iv)$$

where, Y_i=observed banana production level, Y_i^* = predicted level of banana production. The producers' level of technical efficiency is expressed as a value ranging from zero to one (Battese & Coelli, 1995). A farmer who has a value of one is considered to be technically efficient and zero totally inefficient farmer.

The study employed the Stochastic frontier model in investigating the impact of socio-economic and institutional variables on technical efficiency in banana production. The model was utilized to conduct a regression analysis using the efficiency scores as the dependent variable and socio-economic and institutional variables as the independent variables. The connection between socio-economic variables, institutional variables and technical efficiency were analyzed using stochastic frontier model and was applied as below:

$$Y_i^* = X_i'\beta + \cup_i \dots \dots \dots (v)$$

$$Y_i = Y_i^* \; if \; Y_i^* < 0 \dots \dots \dots (vi)$$

where: $U_i \sim N(0, \sigma^2)$ and β are vectors of explanatory variables and unknown parameters respectively. Y_i^* is a latent variable and Y_i is a technical efficiency score and U_i is the error term.

The stochastic frontier model used in the analysis was as in equation (x) below:

$$TE_i = \delta_0 + \delta_1 X_1 + \delta_2 X_2 + \delta_3 X_3 + \delta_4 X_4 + \cdots + \delta_9 X_9 + \omega \dots \dots \dots (vii)$$

where, TE_i= technical efficiency, δ_0 is the intercept of the function while δ_1, δ_2 , … δ_9 are unknown scalar parameters to be assessed and *X1, X2, X3, X4, X5, X6, X7, X8, X9,* are age, gender, education, farming experience, household size, credit access, access to extension services, group membership and access to market. The ω is the error term which is presumed to be normally distributed.

RESULTS AND DISCUSSION

Summary of descriptive statistics of variables used

Table 1 shows the summary of the descriptive statistics of the variables.

Table 1. Summary Descriptive statistics of the variables

Variable	Observation	Mean	Std. Dev	Min	Max
Land size (acres)	402	0.429353	0.615451	0.1	5
Labour (man days)	402	10.33582	2.127872	7	14
Agrochemicals (wheelbarrows)	402	200.6816	157.2616	5	4600
Planting materials (suckers)	402	195.898	170.0516	10	2300
Age of decision maker	402	53.9403	6.971006	24	85
Gender (1=Male, 0= Female)	402	0.865672	0.34143	0	1
Household size (number)	402	4.169154	1.180153	1	12
Education (Years of schooling)	402	10.89055	2.74756	0	18
Farming experience (years)	402	12.4204	4.014922	3	32
Credit access (1=yes, 0=no)	402	0.572139	0.495385	0	1
Extension Access (1=yes, 0=no)	402	0.144279	0.35181	0	1
Market distance (kilometer)	402	12.24789	4.833484	0	24
Farmer organization (1=yes, 0=no)	402	0.057214	0.232534	0	1

According to the findings of this study, the average size of land under banana production was about 0.4 acres with some smallholder producers having farms as small as 0.1 acres and others as large as 5 acres. This confirms that banana production in Kirinyaga Central Sub County consists of smallholder producers. During this study, it was observed that banana production faced competition from other alternative farming activities. This study's findings indicated that the average total amount of labour was 10 man days ranging from 7 to 14 man days. The average amount of agrochemicals (manure) used in banana production was 200.68 wheelbarrows and it ranged from five to 4,600 wheelbarrows. The mean number of banana suckers grown by the smallholder producers in the study area were 196 per acre ranging from 10 to 2300 suckers. The findings demonstrated that the mean age of smallholder banana producers was 54 years old, ranging from 24 to 85 years alongside standard deviation of 6.771 years.

The findings showed that most of the banana producers surveyed were in the age range of 47 and 61years indicating that the study area has many of the middle aged farmers participating in banana production. This imply that the bulk of farmers are in their prime of life, economically energetic and fruitful age bracket and can therefore carry out successful farming. It is possible that decision makers' age in production of banana is a major determinant in embracing of innovation in the banana sector. This study established that most decision makers among the banana producers were men (86.57%), whereas only 13.43% were female. The mean household size was four people with a least family having one person and 12 people maximum. The results imply that there could be availability of family labour amongst smallholder banana producers in Kirinyaga Central Sub County. The number of people in a family may determine the availability of workers eligible for manual work to perform farm activities mostly during banana planting, distribution of manure, weeding and harvesting. As a result, total number of inhabitants staying in a farmer's home might have an impact on the amount of agricultural production through the availability of manpower and also helps to cut off labour costs.

The sampled banana producers had a mean education level of 10 years of formal education, from 0 up to 18 years range insinuating that some farmers had low levels of education. The highest possible level of schooling a farmer has attained may influence their decision making in the process of production as it impacts the farmer's capacity to receive and make use of the production data offered and to adopt new and advanced technologies. This is in return expected to increase technical efficiencies in production as farmers can make the most of the resources at their disposal to increase yield. According to the outcomes of this study, the mean educational level among respondents is high school. On average, smallholder banana farmers had 12 years of experience in banana production with 3 years as the least, and 33 years at the most. Experienced farmers may offer accurate information and possess in-depth knowledge of banana growing and this would translate to higher technical efficiencies and productivity. There is a possibility that experience is crucial in increasing output because it is normal to expect that the more time one spends working in a given occupation, the better they get at performing tasks.

The findings showed that 42.79% of the producers lacked the ability to obtain financing, compared to 57.21% of those who had access to credit. This imply that majority of the smallholder banana producers in Kirinyaga had accessibility to credit. The study's findings demonstrated that out of the banana growers examined only 5.72% were members in a grower's organization. The majority (94.28%) among the surveyed smallholder banana producers did not belong to a group of banana producers. The findings show that 85.75% of banana farmers did not receive extension services while only 14.43% accessed the services. The study observed that the distance to closest banana market was 12 kilometers on average, ranging from one to 24 kilometers.

Technical Efficiency of Smallholder Banana Farmers

The findings on the Cobb-Douglas stochastic frontier function showed that smallholder banana farmers mean technical efficiency was 83.14%, ranging from 0.93% to 95.45% (Table 2).

Table 2: Technical efficiency of the sampled banana producers

Variable	Obs	Mean	Std. Dev.	Min	Max
TE	402	0.831428	0.127938	0.009346	0.95489

The findings proved that smallholder banana producers in Kirinyaga Central Sub County had varied levels of technical efficiencies. These findings suggest that given the prevailing input level, smallholder banana farmers can still increase current production by 16.86% perhaps through productive management of their orchards. The inefficient producers had technical efficiency score of 0.93%, therefore the farmers could increase their existing output by enhancing technical efficiencies because they are utilizing their resources ineffectively as production is being done. The findings of this study coincide those of Asfaw (2021) who found that tomato producers in Ethiopia had an average technical efficiency of 80.9%. Mairabo *et al*. (2023) found that soybean producers in Nigeria had an average technical efficiency level of 89% indicating that a typical soybean grower in Nigeria could raise yield by up to 11% using the same input combination. Van Hung *et al*. (2022) found that banana farmers' technical efficiency varied in Viet Nam and ranged between 89.68% to 97.81% with an average technical efficiency of 95.92%.

Influence of Production Factors on Banana Production Technical Efficiency

The study sought to analyze the influence of production factors on banana production technical efficiency and the findings were as in Table 3.

Table 3: Cobb Douglas stochastic frontier results of production factors affecting technical efficiency.

Variable	Coefficient	SE	Z	P-Value	95% Confidence interval	
Loglandsize	-0.43839	0.04732	-9.26	0.000	-0.53115	-0.34563

		8				
Logfamily_labour	-0.00337	0.027885	-0.12	0.904	-0.05802	0.051285
Loghired_labour	0.05156	0.046067	1.12	0.263	-0.03873	0.141849
Logplantingmaterials	1.31505	0.053822	24.43	0.000	1.209561	1.420539
Logagrochemicals	0.154664	0.031182	4.96	0.000	0.093549	0.21578
Constant	0.585217	0.260912	2.24	0.025	0.073839	1.096595

The findings of this study showed that land size, planting materials and agrochemicals significantly affected banana production at 5% level of significance (p-value= 0.000<0.05, p-value =0.000<0.05 and p-value=0.000<0.05 for land, banana suckers and manure respectively). The corresponding coefficients for banana plants used along with agrochemical factors were found positive while that on land was negative. The findings of this study indicated that a rise in the amount of land given to banana farming reduces production by 0.438%. This imply that banana production would decrease if farmers increase the land allocated to its production. This finding could imply that it's simpler managing smaller pieces of land under banana for optimum production unlike comparatively bigger land pieces. In addition, family labour may be used in smaller farms while larger farms may require additional costs of engaging hired labourers. It is possible that as the size of banana orchards increase management becomes difficult and therefore farmers tend to keep just small pieces. The negative effect between technical efficiency and land size was attributed
to the worry by farmers that increasing land size their costs of production will also increase. The outcomes of this study are in agreement with those of Eshete & Alamirew (2023) who established a detrimental impact of land area in bread wheat production technical efficiency in Ethiopia. Omondi *et al*. (2020) found that banana farmers who did not participate in groups in Nyamira and Kisii counties had decreased production technical efficiencies with increase in land size. Contrary to this study's findings, land size under maize cultivation was significantly and positively affecting maize production technical efficiency in Rwanda (Narcisse, 2017). Debebe & Dagne (2018) also established that land size under banana cultivation had a positive coefficient but was not significant to banana production technical efficiency implying that land size has no effect on banana production.

During the study it was observed that planting materials (banana suckers) were a necessary input in production. The variable showed a favourable correlation at 1.315. The outcomes implied that increasing the amount of planting materials used will lead to increased banana output by a factor of 1.31505. The findings imply that use of correct number of suckers on a farm may results in achieving maximum production. Based on this study finding, use of more banana suckers would lead increased production since many plants will be harvested. Thus, a producer who plants more banana suckers receives higher banana output. Vinayagamoorthi *et al*. (2019) had similar findings to this study and reported that banana suckers were a factor among smallholder banana farmers in Tamil Nadu, India and affected technical efficiency positively. Banana sucker had noteworthy effect on banana production in Bangladesh where it was reported that a 1% rise in quantity of sucker would raise the banana yields up to 0.29% (Mohiuddin *et al*., 2020).

This study's findings proved that the correlation coefficient for agrochemicals was essential as well as favourable implying that using more agrochemicals would significantly increase production. The findings indicated that a rise with a unit in the usage of agrochemicals increases yields in banana up to 0.154664 units implying that manure is a key input in banana production. Khatiwada & Yadav (2022) found consistent results

that agrochemicals had substantial impact in ginger cultivation technical efficiency. In a different analysis, agrochemicals were discovered to be statistically significant and to have a favourable connection with banana yield, meaning that increasing the amount of manure use causes a rise in levels of technical efficiency in Viet Nam (Van Hung *et al*., 2022). Manure variable was significant and had positive influence to banana production where it was observed that 1% increase manure usage increased banana production technical efficiency by 5.92%. (Vinayagamoorthi *et al*., 2019).

Influence of Socioeconomic and Institutional Factors on Banana Production Technical Efficiency

The effect of selected factors on technical efficiency was ascertained using stochastic frontier model as specified in Equation (*vii*). Age of decision maker variable proved significant at a 5% significance level but had a negative influence on technical efficiency levels. These findings indicate that increasing farmers' age might result in 1.46 decline in banana yield technical efficiency. The findings show that the technical efficiency of older producer is typically less compared to that belonging to younger producer. The elderly farmers are assumed to be more reluctant to take risks associated with production unlike the young people. It is also possible that older individuals lack physical strength and do not easily accept new farming techniques. Conversely, farmers who are younger appear to be enthusiastic, creative, energetic, and risk-takers and may therefore are more likely than older people to be able to change the agriculture sector. They may seek and obtain extension services which helps them to manage the different farming situations earlier. Younger farmers may increase their degree of technical efficiency by investing in innovative and advanced technologies in agriculture, effectively increasing total production. As a result, younger farmers have much higher technical efficiencies. The findings of this study on the age of decision-maker stand consistent with the results of Onuwa *et al*. (2022) which established age had unfavourable effects on cowpea production technical efficiency in Nigeria. Kristof (2022) noted that there was a negative sign in the farmer's age coefficient (-0.002) implying that age and technical efficiency were positively correlated in Namibia. Abubakar and Sule (2019) reported that the inefficiency model was adversely impacted by producers' age, which may have suggested that as producers aged, their technical inefficiency also increased. Findings of this study differed from that of Sabroso & Tamayo (2022) whose work made a technical efficiency estimate in production of coffee in the Philippines, and discovered that farmers' age is positively related to technical efficiency. Table 4 shows the results of cobb Douglas Stochastic Frontier Model.

Table 4: Cobb Douglas stochastic frontier results of socioeconomic and institutional factors affecting technical efficiency.

Variable	Coefficient	SE	Z	P-Value	95% Confidence interval	
Age decision maker	1.460155	0.5030861	2.90	0.004	0.474124	2.446186
Gender of HH	4.487178	4.753675	0.94	0.345	-4.82986	13.80421
Household size	2.216655	1.147693	1.93	0.053	-0.03278	4.466093
Education level	-1.324887	0.6891317	-1.92	0.045	-2.67556	0.025787
Farming experience	-1.711854	0.6702208	-2.55	0.011	-3.02546	-0.39825
Group membership	-27.92273	14.14965	-1.97	0.048	-55.6555	-0.18992
Credit access	-4.887482	3.647082	-1.34	0.180	-12.0356	2.260668
Extension access	-1.761684	5.201832	-0.34	0.735	-11.9571	8.43372
Market distance	-1.583283	0.6186264	-2.56	0.010	-2.79577	-0.3708
Constant	-58.1009	24.43632	-2.38	0.017	-105.995	-10.2066

The findings of this study showed that household size had adverse effects on smallholder banana production technical efficiency levels. The findings showed that as household size increases, banana production technical efficiency reduces to the extent of 2.217. During the study it was established that majority of household heads were educated and therefore sent their children to school who then are not involved in active farming and this may lead to decrease in technical efficiency levels. It was established that children participated in production during weekends and on holidays. The study's outcomes coincide with those of Ayuko *et al*. (2023), which highlighted that a rise in family size reduces the level of technical efficiency in fodder productivity in Homabay County, Kenya. Tenaye (2020) found that there existed good correlation between technical inefficiency and size of household showing that bigger families are more technically inefficient. The findings of this study differed those of Rukwe & Zubairu (2019) who reported that the households' size variable had detrimental coefficient with technical efficiency signifying that a rise in household size raises technical efficiency in production of sesame.

The findings of this study disclosed that education variable had favourable effects on level of technical efficiency. The findings indicated that increasing smallholder banana farmers' education level by a unit would increase banana production technical efficiency by 1.325 units, *ceteris puribus*. It is possible that education access improves the management and technical abilities of farmers and raises the household's capacity to make use of new and current technology and achieve better levels of efficiency. Education is supposed to help farmers allocate inputs efficiently and also in better management of banana orchards. The outcomes of this research agree with those presented by Dessale (2019) who noted that education had positive effects on wheat production technical efficiency in Ethiopia implying that technical efficiency level of less educated farmers was low compared to those who are more educated. Van Hung *et al*. (2022) as well reported education variable had a good and significant impact on banana production technical efficiency in Viet Nam. In addition, Kristof (2022) found that a strong connection existed between the farmers' technical farm efficiency and their level of education. Muzeza *et al*. (2023) determined that education had a negative coefficient, meaning that A1 maize farmers with greater education had higher technical efficiencies than the less educated farmers. Technical inefficiencies are assumed to decrease as education level increases since it improves farmers' abilities to acquire technical knowledge and apply it in production. Contrary to outcomes of this study, Mairabo *et al*. (2023) pointed out that the technical efficiency of soybean growers is unaffected by education in Nigeria. Eshete & Alamirew (2023) observed that education variable was negative and insignificant to bread wheat production technical efficiency. Tamirat & Tadele (2023) also found that the technical inefficiency had a negative relationship with the education level of coffee farmers meaning that farmers' level of education didn't affect their levels of technical efficiencies.

The outcomes of this investigation depict that banana farming experience factor was relevant at 5% level of significance and produced favourable impact on the level of technical efficiency. The findings showed that a year's worth of additional farming experience increases smallholder banana production technical efficiency by a factor of
1.712. This could be because more work experience leads to more job knowledge and improves how smallholder banana farmers perform tasks on their orchards. This study's outcomes are in line with those of Muzeza *et al*. (2023) which established a negative coefficient on the experience variable, implying that the more knowledgeable A1 smallholder maize farmer was more technically efficient. Similarly, Mairabo *et al*. (2023) established experience of producers influenced technical efficiency of soybean production positively.

The study's findings showed that group membership variable was negative implying that membership to farmer group affected technical efficiency positively. This study's outcomes demonstrate that belonging to farmer's organization boosts the technical efficiency of banana production by a factor 27.92. It is possible that

participation by smallholder farmers in group organizations and cooperatives has a substantial impact on raising production technical efficiency levels. This could imply that farmers who belong to these groups are more productive than those who do not. Membership ensures sharing of valuable information among members, collective selling of farmer produce, access to current market information and bargaining power to be able to get good prices for the products. These findings are in line with Ofori-Appiah (2022), who claimed that group participation possessed favourable influence on the technical efficiency of pineapple production in Ghana. In Nepal, the coefficient of cooperative participation was discovered to be negative, meaning that ginger the technical efficiency of producers who belong to such groups is higher than that of nonmember producers (Khatiwada & Yadav, 2022). Therefore, there is need for development of initiatives to entice farmers to join and take part in banana cooperatives or other farmer associations or groups within the region of study. Adeoye (2020) analyzed characteristics of vegetable production efficiency in Nigeria and found membership to farmer cooperative significantly and positively influenced technical efficiency indicating that an increase in pepper production efficiency resulted from membership in a cooperative society. Membership to the farmer organization was discovered to be positively significant to fodder production in Homabay, Kenya implying that farmers who are part of the farmer group have a 4.3% increase in technical efficiency (Ayuko *et al*., 2023).

The findings of this study shows that proximity to the market affects smallholder banana farmers' technical efficien cy positively. According to the findings, an increase of one unit in the distance to the closest market will translate to a rise in technical efficiency of banana production with a factor of 1.583, *ceteris paribus*. Possible reason for this is that farmers perceive that they get better higher prices from urban areas unlike selling produce at farm gate. For smallholder farmers, the distance to the nearest market is a crucial standard measure of the viability of the market for both inputs and outputs and access to market information. Outcomes of this study contradict those presented by Martey *et al*. (2019), where it was discovered that distance to market as having adverse impacts on technical efficiencies in maize production. The findings of this study on market distance contradict those of Endalew *et al*. (2022) which reported the distance to market significantly and adversely impacted teff production technical efficiency. Distance to the market was important and showed detrimental correlation with tomato production technical efficiency in Asaita district, Ethiopia, indicating that the most effective farmer is one who is close to nearest marketplace as opposed to one who lives a long way off (Asfaw, 2021). How far the farm is from the nearest market had positive coefficient but showed insignificant effects to banana production technical efficiency in Ethiopia (Debebe & Dagne, 2018).

CONCLUSIONS

The study aimed at determining influence of production, socio-economic as well as institutional factors on smallholder banana producers' technical efficiency in Kirinyaga Central Sub County. Banana production and technical efficiency can be increased by increasing number of banana suckers planted, increasing manure usage and maintaining land size allocated to banana production. This study further found that banana production technical efficiency was influenced by age of decision maker, experience of the farmer, education level attained, size of households, distance traveled to nearest banana market and membership to farmer group. It was found that an increase in banana farmers' experience, education level, distance to market, and membership in farmer groups would increase banana production technical efficiency, while the increase in age of decision maker and household size decreases banana production technical efficiency. The study established that smallholder banana producers had varied technical efficiencies ranging from 0.93% to 95.45%. Further, the study noted that smallholder banana farmers produced banana at 83.14% technical efficiency level thus they had the potential of increasing their production level by 16.86% given the available resources in the Sub County.

RECOMMENDATIONS

The following recommendations were given in light of the findings of the study:

i. To improve banana production technical efficiency smallholder producers ought to be motivated to increase agrochemical usage as well as more banana suckers.

ii. There is need for people with high levels of education to venture into banana production since smallholder banana producers with high levels of education had high levels of production efficiencies.

iii. Farmers ought to be urged to form and join banana cooperatives or other farmer organizations in order to take advantage of opportunities that result from knowledge sharing and shared experiences, receive various agricultural trainings, and receive other financial support that will ultimately result in technical efficiencies.

iv. Make extension services more accessible to smallholder banana farmers so they have access to the most recent, pertinent, and crucial knowledge about banana farming. There is also a need for deploying a greater number of extension officers to rural regions. to help farmers in need of extension services.

v. There were varying technical efficiencies among smallholder banana producers and therefore the inefficient farmers could increase existing production output through enhancing technical efficiency since they are they are utilizing their resources ineffectively as production is being done. Certain producers in the area of study produced higher yields as well as attained greater levels of technical efficiency; as a result, these farmers can be effectively used to demonstrate the value of sound agricultural practices in bridging the disparity between farmers who are technically efficient and those who are not.

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