Influence of Farm Size on Adoption of Improved Coffee Varieties by Smallholder Farmers in Mathira East Sub-County, Nyeri County, Kenya

Njeru, E.W.; Munyua, C.N.; Kinuthia L. N

Department of Applied Community and Development Studies, Egerton University, Kenya

DOI: https://dx.doi.org/10.47772/IJRISS.2025.905000255

Received: 16 April 2025; Accepted: 24 April 2025; Published: 10 June 2025

ABSTRACT

Coffee productivity in Kenya has been on decline while the global demand has been on the rise. Mathira East Sub-County has not been left out with notable decline since the 1980s negatively affecting the local and national economy. The decline is attributed to rising costs of farming and drop in yield from traditional coffee varieties. Despite introduction of improved coffee varieties, productivity has remained low. Thus, this paper investigated the influence of farm size on the adoption of the improved coffee varieties by smallholder farmers in Mathira East Sub- County. The study adopted the cross-sectional research design involving key coffee farming household informants. The results showed that most farmers with larger farms had adopted improved varieties. The binary logistic regression results indicated that farm size significantly influences adoption of the improved coffee varieties at p value of 0.011. This finding is attributed to the ability of farmers to diversify part of their land into improved varieties. The study recommends that the county government of Nyeri should enhance extension services to educate and train farmers on how to graft traditional coffee bushes with improved varieties. This could help farmers with small farm sizes to diversify part of their coffee into improved varieties.

Keywords: Adoption, Farm size, Influence, Smallholder farmer, Cultivar, Improved varieties

INTRODUCTION

Coffee is one of the most traded agricultural commodities and a staple beverage for several people globally (Adong et al., 2024). The International Coffee Organization [ICO] (2023) reports on two main traded species; the *Coffea arabica* (Arabica coffee) and *Coffea canephora* (Robusta coffee) accounting for approximately 70% of coffee production. According to the ICO (2023) report, global coffee production decreased by 1.4% to 168.5 million bags in coffee year 2021/22. On the other hand, world coffee consumption increased by 4.2% to 175.6 million bags in the coffee year 2021/22. This suggests resilient demand for coffee worldwide especially with the emerging markets such as Algeria, Australia, Russia and South Korea. In Africa, coffee is produced in Eastern, Central and parts of West Africa. Africa contributes 11.4% of world coffee with the largest production coming from Ethiopia and Uganda (ICO, 2023). The ICO report shows that Kenya's coffee production accounts for only 5% of Africa's overall production recording a 9.6 per cent decline in production in the year 2021/2022.

Coffee was first introduced in Kenya by French missionaries around 1900 AD (Mwangi, 1983). The crop is grown in three zones in Kenya: the high altitude (over 1700 m above sea level) such as Muranga, Nyeri, Kirinyaga, Nandi hills and Meru central; medium altitude (between 1580 m and 1760 m) such as Embu, Machakos and Makueni; and low altitude (1520m–1580m such as Wundanyi in Taita- Taveta (Jack, 2011). In addition, two distinct sectors are involved in coffee production namely; estates characterized by large coffee plantations comprising several hectares and the smallholder producers owning less than five hectares and often managed under cooperative societies.

The traditional coffee cultivars in Kenya are SL28 and SL34 (Mwangi, 1983). These varieties are susceptible to Coffee Berry (CBD) and Coffee Leaf Rust (CLR) diseases. Coffee Berry Disease, infects all stages of the crop

from flowers to ripe fruits and occasionally leaves, but highest crop losses occur when green berries are infected resulting to the formation of dark sunken lesions with sporulation which causes their premature dropping and mummification (Hindorf & Omondi, 2011). Coffee Leaf Rust mainly attacks leaves forming yellow pustules resulting to defoliation. CLF causes significant economic losses reported in over fifty coffee growing countries in the world.

To cope with challenges associated with coffee production, improved varieties that are resistant to CBD and CLR have been developed. Ruiru 11 was released to farmers in 1985 (World Coffee Research [WCR] 2024). Ruiru 11 is also reputed for its high yielding potential thereby combining the benefits of high production and reduced cost of production. Batian variety was released in 2010 and in addition to being resistant to CBD and CLR has early maturity periods than SL28 or Ruiru 11. The variety is of high quality and is suited to all ecological zones (WCR, 2024). Despite these efforts and the desirable qualities of Ruiru 11 and Batian varieties, adoption has been low.

Several studies have reported on factors influencing adoption of agricultural innovations. Ullah et al. (2018) reported that farmer's age, education, farm size among other factors have an effect on adoption of improved varieties. Different studies by Addai et al. (2021), Kidanemariam (2011) and Klerkx et al. (2010) report farm size as an important factor affecting adoption of agricultural technologies. As such, vast literature identifies farm size as a main socio-economic factor affecting adoption of agricultural technologies.

The effects of farm size vary depending on the type of technology being introduced and the institutional setting of the local community (Akudugu et al., 2012; Nanda et al., 2018). This means that farmers who have relatively large farm size will have more initiative in adopting a new agricultural production technology and the reverse is true for small size farmland. Farmers with large farm sizes have been found to be more likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size.

On the other hand, there are other studies that indicate a non-significant influence of large farm size on adoption of new agricultural technologies. Daudi et al. (2018) report that small farm size may provide an incentive to adopt a technology especially in the case of an input-intensive innovation such as a labour-intensive or land-saving technology. Such studies imply that adoption may take place regardless of farmers' scale of operation. Kariyasa and Dewi (2013) also found that extensive land holdings had no significant effect on adoption probability. The study considered total farm size on which the new technology is practiced and the number of coffee bushes to predict the level of adoption.

Coffee continues to play a key role in the economy of Nyeri County and the County government has identified coffee as a flagship project to contribute towards improvement of livelihoods (CGN, 2013). The decline in production from disease, low productivity and high cost of production is a threat to this important agricultural sub sector. Little information on how farm size has affected adoption of Ruiru 11 and Batian improved coffee varieties in Mathira East sub-county is available. Hence, this study examines the influence of farm size on the adoption of improved coffee varieties among smallholder farmers in Mathira East sub-County, Nyeri County, Kenya.

METHODOLOGY

Location of the Study

The study was conducted in Mathira East Sub-County of Nyeri County (Figure 1). It is located on Latitude 0° 25' 0" S and Longitude of 36° 57' 0" E. This sub-County lies 25km East from Nyeri town, which is the headquarters of the Nyeri County. It has an area of 130.9 km^2 out of which 109.4 km^2 is arable land. The rainfall pattern is bimodal whereby long rains fall from March to May and short rains from October to December annually. Annual rainfall ranges from 800-1400mm while temperatures range from 18-24ºC. The main enterprises in the area are coffee farming covering 2080 hectare (Ha), tea farming (1996 Ha), maize (1240 Ha), potatoes (430 Ha), bananas (450 Ha) and horticulture (301 Ha), Dairy, tourism and trade. Coffee farming is one of the major economic activities making the area very suitable for this study.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

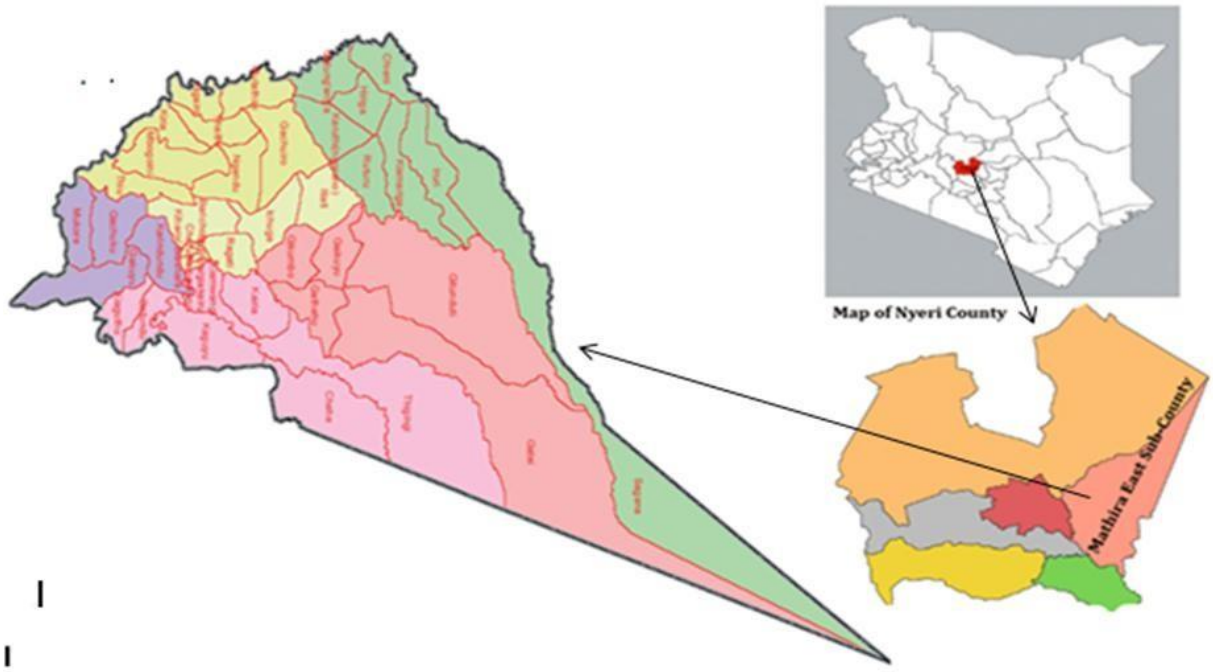

Figure 1: Map showing the study area, Mathira East Sub- County

METHODS

The target population for this study was smallholder coffee farmers. The accessible population was 13,715 farmers registered in coffee societies within the administrative boundaries of Mathira East sub-County namely Iria-ini, Gikanda, Baricho, Mugaga, Gakuyu, and Kiama coffee societies. Sampling frame was obtained from the six coffee societies and a sample size (n) of farmers who participated in the study was determined using Yamane (1967) formula.

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

Where;

n = the sample size

N= population (13,715) and, e= Standard error (0.05)

$$n = \frac{13,715}{1+13,715(0.05)^2}$$

$$n = 309$$

Proportionate sampling was carried out to determine the respondents from each coffee society. At the society level, simple random sampling was used to select those who were involved in the study.

Table 1: Smallholder Farmer Sample Proportions from the Six Coffee Societies (N=309)

Coffee Society	No. of farmers	Proportion	Sample size
Iria-ini	1646	0.12	37
Gikanda	2469	0.18	56
Barichu	3703	0.26	83

Mugaga	3703	0.26	80
Gakuyu	1379	0.10	31
Kiama	1097	0.08	25
TOTAL	**13715**	**1.0**	**309**

Data Collection and Analysis

A semi-structured questionnaire was used to collect data from the smallholder farmers. The closed-ended items were included because they allowed uniformity of responses while open-ended items enabled collection of additional information by asking follow-up questions. The questionnaire was piloted for reliability in Mukurwe-ini sub-County that has similar characteristics to the study location. A pilot study sample representing 10% of the project sample size yielded a Cronbach's alpha reliability coefficient of 0.888. It was deemed reliable as its reliability was above the 0.7 threshold as recommended by Panayides (2013).

The purpose of the study was explained to the respondents, confidentiality of their responses assured and their consent to participate in the study sought. Dates and venues for administration of the questionnaire were set in consultation with the respondents. The farmers were first taken through the modalities of filling the questionnaire then given time to fill. The researcher guided respondents who had problems filling the questionnaire.

The collected data was screened for errors and a data file was created using the Statistical Package for Social Sciences (SPSS) version 27. The coded data were then keyed into the data file. Qualitative data generated by the open-ended items in the questionnaire were organized in themes pertinent to the study and then described, summarized using frequencies and percentages. The influence of farm size was determined using binary logistic regression and the hypothesis tested at $p \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

Data was collected from 309 smallholder coffee farmers. Consequently, a total of 309 questionnaires were administered to the farmers. 99% of the administered questionnaires were filled and returned. The high response rate was achieved because data was collected when most farmers were selling coffee in their factories, good rapport and assistance from the extension officers, factory managers and local administration (chiefs and their assistants) to identify and locate respondents.

Demographic Characteristics of respondents

Demographic characteristics examined were gender, age and level of education and served to provide basic information on the respondents.

Table 2: Demographic Characteristics of the Smallholder Farmers (Study Data, 2023)

Characteristic	**Frequency**	**Percentage**
Gender		
Male	215	70.7
Female	89	29.3
Age(years)		
25 and below	5	1.6
26 – 35	51	16.6
36 -45	61	19.8
46 – 55	70	22.7

Above 55	121	39.3
Education level		
None	12	4.1
Primary	109	37.2
Secondary	91	31.1
College	77	26.3
University	4	1.4

The results show that more than two thirds (70.7%) of the farmers were males while only a few (29.3%) were females. This show gender bias in participation in coffee farming in favour of the males implying that decision making on adoption is largely dependent on males. The results support those of Kamau et al. (2017) who established that most coffee farms in Muranga, Kenya were owned by men. Coffee farming involves use of land and the tenure systems practiced in the region that traditionally allowed only men to own and or inherit land. This may explain the gender bias in favour of males observed.

The results also show that majority (62.0%) of the respondents were above 45 years old. The results suggest while youth may be more likely to adopt improved coffee varieties, coffee farming may not be attractive to them. The results concur with those of Brooks et al. (2014) who observed that young people in Africa avoid engaging in agriculture. This result may be explained by small land sizes still held by their parents thereby denying them the opportunity to engage in coffee farming.

On the level of education, 4.1% had no education. The majority of the respondents had attained primary (37.2%) and secondary (31.1%) school level of education. Slightly over a quarter (26.1%) were college graduates while very few (1.4%) had attained university level of education. The results indicate that slightly more than a quarter (27.5%) of the farmers had post-secondary school certificates. These results suggest that coffee farming was not attractive to persons who attained education higher than secondary school. The results are in harmony with those of Oduro-Ofori et al. (2014) which showed that most small-scale farmers in Ghana had just basic education.

Influence of Farm Size on the Adoption of Improved Coffee varieties

Land owned by the smallholder farmers in the study area was in the range of 0.25 and 10 acres with a mean of 2.35 acres (SD = 1.73). The results are presented in table 3.

Table 3: Sizes of Land Owned by farmers (Study Data, 2023)

Size	**Frequency**	**Percentage**
2 acres and below	178	58.9
2.1 to 4.0	93	30.8
4.1 to 6.0	24	7.9
6.1 acres and above	7	2.3
Total	**302**	**100**

The results indicate that more than a half (58.9%) of the farmers had farms of 2 acres and below while very few (2.3%) had farms of more than 6 acres. These results reveal that the farms of most of the farmers were small in size, which is likely to result in low capacity to adopt improved coffee varieties. The results concur with those of FAO (2015) which revealed that the category of farmers owning small pieces of land of less than 5 acres grow subsistence crops and one or two cash crops.

Data on the land size under coffee was collected and is presented in table 4

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue V May 2025

Table 4: Percentage of Land under Coffee (Study Data, 2023)

Land under coffee	**Frequency**	**Percentage**
25% and below	36	12.5
26 – 50	115	40.1
51- 75	108	37.6
76 - 100%	28	9.8
Total	**287**	**100**

The results indicated that 52.6% of farmers have less than 50% of their land under coffee. The average percentage of land under coffee was 54.9%. The results support those of a study in Nyeri County by Njeri (2015) which revealed that small scale coffee farmers did not put all their land under coffee but had ventured into alternative agricultural activities. This diversification provided farmers with food and alternative income to cushion them against fluctuation in coffee prices and irregular payment of proceeds from coffee. Data on adoption of various coffee varieties by year is presented on table 5.

The farmers were categorized as adopters or non-adopters of the improved coffee varieties based of the number of Batian and Ruiru11 bushes in the farm. Those who had 50 bushes and above of any or both of the two varieties were considered as adopters. Those who had less than 50 Batian, Ruiru11 or a combination of both were categorized as non-adopters. The results are shown in table 5.

Table 5: Adoption of Improved Coffee Varieties (Study Data, 2023)

Category	**Frequency**	**Percentage**
Adopter (50 bushes and above)	84	27.5
Non-adopter (<50 bushes)	222	72.5
Total	**306**	**100**

The results show that nearly three quarters (72.5%) of the farmers were non-adopters while slightly over quarters (27.5%) were adopters. The results indicate that very few farmers have adopted the improved Ruiru 11 and Batian varieties. These results concur with those of a study by Maundu and Karugu (2018) which showed that majority of the small-scale farmers in Nyeri County grow SL coffee varieties.

The influence of farm size on the adoption of improved coffee varieties was established using binary logistic regression. The statistical procedure was selected because farm size was measured in acres (continuous data), while adoption was dichotomous (adopter, non-adopter) categorical data. Senaviratna et al. (2019) recommends the procedure when establishing association between continuous and categorical dichotomous data. The results of the logistic regression tests are presented in table 6.

Table 6: Logistic Regression Test Results between Farm size and Adoption of Improved Coffee Varieties (Study Data, 2023)

Scale	**B**	**S.E.**	**Wald**	**Df**	**p-value**	**Exp(B)**
Farm size	.221	.087	6.458	1	.011	1.047
Constant	.467	.221	4.469	1	.035	1.596

Logistic regression analysis was employed to predict the probability that farm size has influence on the adoption of improved coffee varieties. The results showed a positive relationship between farm size and adoption of improved coffee varieties. From the above table, the coefficient(B) for farm size was 0.221 with a standard error

(SE) of 0.087, the associated p value of 0.011 and the odds ratio or Exp (B) was 1.047. The above results indicate that for every unit increase in farm size, the outcome odds increase by a factor of 1.047 when all other factors are held constant. The p value of 0.011 indicates that farm size has statistically significant influence on adoption of improved coffee varieties. Thus, the null hypothesis that farm size has no statistically significant influence on the adoption of improved coffee varieties was rejected at $p \leq .05$.

The results revealed that farm size has positive and significant influence on the probability of adoption of improved coffee varieties. This result support those of a study conducted among small scale coffee farmers in Ethiopia by Kebedom and Ayalew (2014) which revealed that farm size was a significant predictor of adoption of new coffee varieties. Atinafu et al. (2022) also noted that farm size had a positive effect on the probability of technology adoption for the poor, but no significant effect for richer farmers.

Deducing from the results, farm size affects adoption of improved coffee varieties because most of the farmers have been in the coffee sector for many years and planted other varieties in their farms. Most of the farms in Mathira East sub- county are small while adopting improved varieties requires more land. This implies that space for improved coffee varieties can only be created by either uprooting what a farmer has planted or grafting the planted variety.

CONCLUSION AND RECOMMENDATIONS

The analyses developed in this research prove useful and provide evidence on an important issue concerning the adoption of improved coffee varieties. Results obtained show much concurrence with previous empirical results in the literature. Farm size emerged as a significant factor that influences the adoption of improved coffee varieties. This is because smallholder farmers with slightly bigger farms were able to diversify into other varieties without necessarily disrupting the existing enterprises. This study makes a conclusion that farmers with large farm size are likely to adopt a new coffee variety as they can afford to devote part of their land to try new technology unlike those with less farm sizes.

In light of this study's findings, the following recommendations were made:

1. The coffee cooperatives and the coffee factories in conjunction with the County Government of Nyeri should start clonal gardens where farmers can get grafted seedlings and training for growing and managing improved coffee varieties.

2. The County Government of Nyeri should enhance extension services to educate and train farmers on how to graft traditional bushes with improved varieties. This could help farmers with small farm sizes to diversify part of their coffee into improved varieties. This will also offer an affordable option for adopting improved varieties.

3. Farmers growing traditional coffee varieties should be encouraged to adopt cost-effective ways of improving productivity per tree so that they can increase incomes and improve their livelihoods. Adopting high yield disease resistant varieties like Ruiru 11 and Batian and input intensive management are possible solutions.

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