

Original Research Article

Farmers' Information-inputs and their sway on Coffee Productivity in the West of Rift, Kenya

ABSTRACT

Coffee (*Coffea arabica*) is an important cash crop for export earnings and livelihoods in Kenya. Coffee production has, however, declined from about 130,000 metric tons in the 1990s to about 43,000 in 2018, partly attributed to low farm-level productivity. Previous studies further attribute this to weak adherence to agronomic practices. The current study investigated the farmer's information inputs, as a precursor of agronomic practices, for their potential sway on coffee productivity. The study assessed the level of information inputs among smallholder farmers and its potential influence on coffee productivity in areas west of Rift, Kenya. Data on information inputs for best practices in cultivation, soil fertility management, canopy management, intensive land use, crop protection and cherry harvesting were collected from 140 participants sampled through purposive and stratified random sampling techniques. The study adopted an ex post facto survey design and utilized semi-structured interview schedules for data gathering. Relationships between information inputs and productivity were estimated using chi squares' Contingency coefficient and the more robust Welch's ANOVA and its associated measure of strength, Eta squared (η^2). Results suggest diverse levels of information inputs among the smallholder farmers. Information-inputs on soil fertility management showed a particularly strong association with yields (Welch $P < .001$, $\eta^2 = .108$). Information-inputs on canopy management had significant association with cherry quality ($P < .05$, $\eta^2 = .078$). Other information-input areas showed none to small associations with yield and quality. The study concludes that information inputs in smallholder coffee farms are at different levels and have a direct consequence on coffee yields and quality. It is recommended that the delivery of information inputs by extension agents should emphasize soil fertility management and canopy management for enhanced coffee productivity. Further study to unearth the latent facts for the differentiated information-input levels is recommended.

Keywords: Information-inputs, farmers' practices, coffee, yields, quality

1. INTRODUCTION

1.1 Background Information

Coffee (*Coffea arabica*) is one of the most important cash crops grown in Kenya and contributes an estimated 10% of total agricultural export earnings [1]. The coffee sub-sector is important in Kenya regarding income generation, employment creation, foreign exchange earnings and tax revenues [2]. All Kenyan coffee is rich Arabica coffee, grown in rich volcanic soils that are found in the Kenyan highlands. The crop was introduced to Kenya

around 1893 in plantations but smallholder cultivation started around 1935. It is estimated that 75% of Kenya's coffee is produced by small scale farmers with 0.3 to 0.5 hectares [3]. The smallholder coffee production gained momentum in the late 1950s following the adoption of the Swynnerton plan policy blueprint which encouraged smallholder farmers in 1954 [2].

According to Bagal *et al.* (2013) as cited by [4] Kenya's Arabica coffee is among the highest-rated coffee in the world due to its high quality. Coffee is an important export commodity and a major source of income for smallholder farmers with less than 5ha. Coffee production has, however, declined from about 130,000 metric tonnes per year in the early 1990s to about 60,000 metric tonnes [3]. This decline suggests that there may have been either a decline in the area under coffee or a decline in its productivity or both. Some reports have attributed the decline in production to a lack of agricultural training system and weak public sector support for the industry [3]. Author [5] attributes the decline to the high cost of inputs, coffee price volatility, ageing farmers, obsolete processing technology, erratic weather patterns, poor governance of cooperatives and low farm yields. The current study focuses on the factors that may be responsible for the low yields at the farm level in the areas to the west of the rift in Kenya.

Kenya is a major exporter of quality coffee to the rest of the world. About 31% of Kenya's coffee is exported to Germany and the United States of America [6]. In the year 2018 the other major importers of Kenyan coffee included; Belgium (14%), the Republic of Korea (12%) and Sweden (8%) as illustrated in Figure 1. The exports earned Kenya about 23 billion Kenyan shillings in the period 2017/2018 from an export volume of about 43,289 metric tons (Table 1). This made a significant contribution to smallholder farmers' livelihoods. In light of the significance of the sub-sector to livelihoods, its productivity is of concern to many players in the sub-sector. The literature reviewed reveals that there are a number of factors that determine the productivity of Kenya's smallholder coffee.

Table 1: Kenya's Coffee Exports 2012-2018

Year	Net weights (Tonnes)	Value (Billion Kshs.)
2012/2013	49031	18.209
2013/2014	47175	19.733
2014/2015	44064	21.010
2015/2016	44342	20.893
2016/2017	43378	23.468
2017/2018	43289	23.307

(Source: International Coffee Council, 2019)

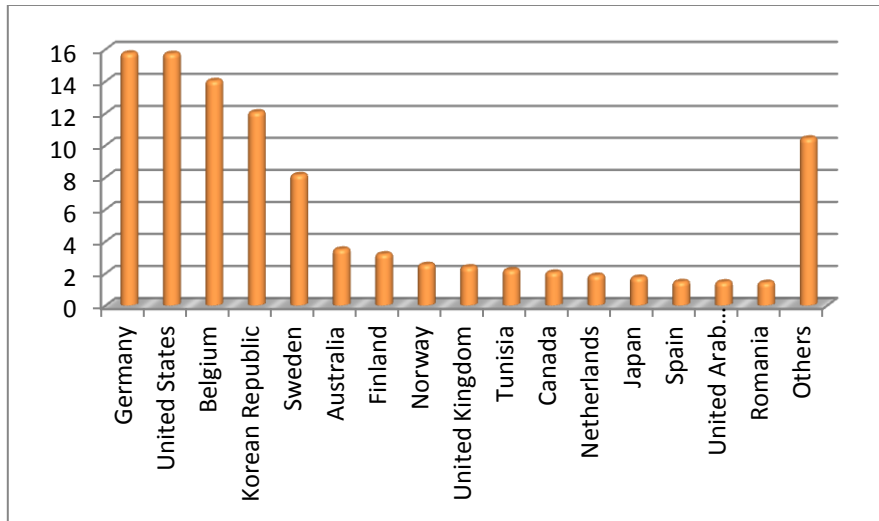


Fig. 1: Kenya's Coffee Export Destinations in 2017/2018

(Source: compiled from International Coffee Council, 2019)

1.2 Determinants of Productivity

There has been a decline in coffee production in Kenya over the last few years, partly due to declining productivity. Authors [7] reported that coffee production in Kenya declined from 54,000 tonnes of clean coffee in 2008/2009 to 36,300 tonnes in 2010/2011. It only increased slightly to 39,800 tonnes in 2013. The declines have been attributed partly to a reduction in the area under coffee and partly to a decline in productivity [7]. The low productivity in turn has been blamed on the low application of farm inputs, poor farming practices and a lack of confidence in the management of the coffee sub-sector among other reasons. The current study investigates the potential influence of information-inputs that are used in the farming practices on the productivity of the coffee in the West of Rift Counties of Kericho and Nandi in Kenya. The study has implications on the actions undertaken or to be undertaken by stakeholders in the sub-sector. According to Kenya Coffee Traders Association, [8], Kenya's coffee productivity based on land resource stood at 5.4 bags/ha. This was a relatively low productivity compared to that of neighbouring Ethiopia at 6.5 bags/ha and that of other Arabica-producing countries such as Colombia at 10.7 bags/ha and Honduras at 11.2 bags/ha.

According to [9], coffee is a high-value commodity and a major contributor to Kenya's economy. However, many smallholder producers remain poor because of the low productivity of coffee. The low productivity has also been attributed to losses due to pests and diseases such as coffee berry diseases & leaf rust and high production costs. It has also been blamed on low use of farm inputs, marketing problems and poor management of farmers' cooperatives [9]. Author [7] also linked the low productivity to international market conditions. Authors [10] attributed it to fluctuations in world prices, production practices used by farmers, pests and diseases and lack of credits for farmers. Elsewhere, [11] suggested that there were strong links between the declining productivity with the effects of liberalization of coffee milling from 1995. Lack of capital, high cost of production, competition from horticultural crops, erratic weather and high cost of labour have also been cited as negatively impacting productivity [11]. Author [10] further identified land fragmentation as a contributory factor. In another study [12] reported a significant influence on productivity from farmers' lack of consultation with extension service providers, lack of credit and lack of income from sources other than coffee. Another author, [13] singled out the role of poor management of Farmers Cooperatives in contributing to the decline of smallholder coffee

production. These observations by several writers suggest a mixed bag of reasons for the low coffee productivity.

An examination of the data available from the Central Bank of Kenya, CBK [14] on the export volumes from the year 2009 to 2019 indicates that the volume of coffee exports declined from about 55,000 tons in 2009 to about 39,000 tons of clean coffee in 2019 as illustrated in Figure 2. The average coffee prices per ton have also fluctuated over the period. In the year 2009, the average price was about Kenya shillings (Kshs.) 254,000, it increased to 551,000 in 2011 and declined to about 336,000 in 2013 [14] as illustrated in Figure 2. The value of Kenya's coffee exports has similarly shown mixed signals following the patterns exhibited by the fluctuating prices. These fluctuations in the value of coffee exports have implications on the livelihoods of the smallholder farmers who constitute 75% of the coffee producers in the country [5]. The low value of exports is a disincentive to smallholder production. For small scale farmers, the peak harvesting periods require immediate finances for the hiring of labour.

Kenya's peak harvesting seasons are bimodal; April to June for the East of Rift and October to December for the areas to the West of Rift. Consequently, the marketing of coffee is mostly concentrated from March to June as illustrated in Figure 3. This pattern of sales being concentrated on some few months of the year has implications on the cash flow situation for the smallholder capital-weak coffee producers and arguably is a factor in its productivity.

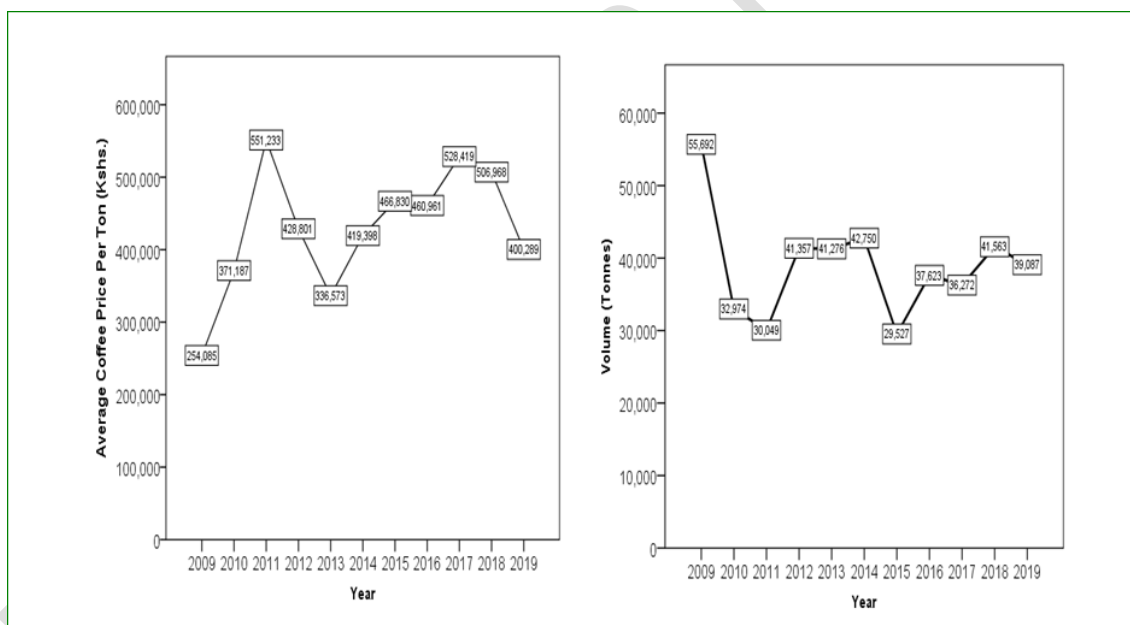


Fig. 2. Coffee prices and Kenya's coffee Export volumes (2009-2019)
(Source: Data compiled from Central Bank of Kenya, 2020)

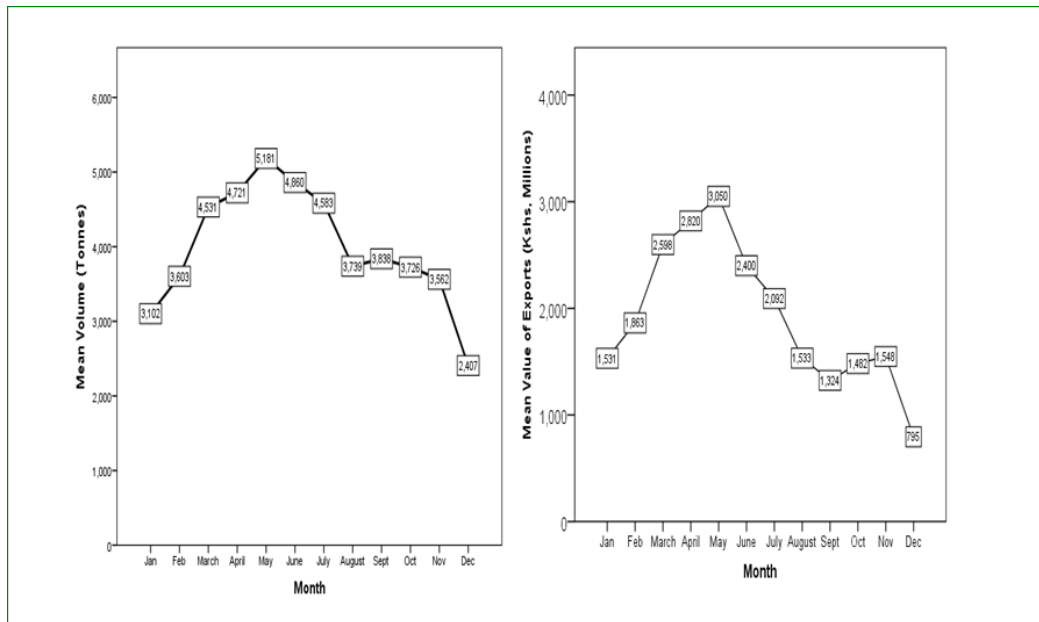


Figure 3: Kenya's long-term mean coffee export volumes and value/month (2009-2019)
(Source: Data compiled from Central Bank of Kenya, 2020)

In summary, a review of the literature on coffee production suggests that socio-economic factors, international market conditions (external factors) and farm-level production practices have contributed to low coffee productivity among smallholder coffee producers in Kenya.

1.3 Statement of the Problem

Diverse sources of literature on the role of coffee in Kenya are in agreement that coffee is an important crop for smallholder farmers' livelihoods and Kenya's economy. Despite its important role, however, Kenya's coffee production has experienced a decline from 130,000 metric tons of clean coffee in 1988/89 to 36,000 in 2015/2016 [10]. The decline in production has been linked to several factors; one of which is farmers' production practices ([6]; [10]). The farmers' production practices that may be responsible for the low coffee productivity have been the focus of the country's agricultural extension system, with many interventions having been implemented to address the issues. The coffee productivity in Kenya has, however, remained relatively low compared to the other coffee-producing countries [8]. Within the country, the national average clean coffee yield is estimated at 302 kgs/ha and yet the national average for estates is 556 kg/ha [6], indicating a big difference in productivity levels between the smallholder coffee producers and the large scale coffee estates.

Farmers' production practices have been partly blamed for the low coffee productivity among smallholder farmers ([6]; [5]). These farmers' agricultural practices responsible for low productivity can be broadly grouped into five categories; cultivation practices, soil fertility management practices, crop protection practices, canopy management practices and cherry harvesting practices [1]. These practices have been collectively blamed for contributing to the low productivity of coffee among small scale farmers with little distinction from the farmers' perspective as to which practice could be the most important culprit. There is inadequate understanding of the level of information-inputs possessed by the farmers to adequately handle the agronomic practices. Whereas each of these practices has a role to play in coffee productivity, little is documented from the farmers' perspective on the information stock held by the smallholder farmers on these agronomic practices that needs to be addressed for productivity improvement. To what extent information on each of these

practices contributes to the productivity based on the farmers' actual practices is little understood; a gap the current study purposed to address. An understanding of the strength of each of these information-input areas in influencing coffee productivity in the West of Rift, Kenya, will be of value to the agricultural extension system in formulating targeted interventions that are likely to yield quick results.

1.4 Purpose of the study

The purpose of the study was to investigate the farmers' information-inputs on coffee production, practices and their sway on coffee productivity in the West of Rift, Kenya. The study sought to address the following specific objectives:

- i) Assess the level of information inputs among smallholder farmers on coffee agronomic best-practices in West of Rift, Kenya.
- ii) Investigate the potential influence of farmers' information-inputs on the productivity of coffee in the areas west of Rift in Kenya

1.5 Theoretical Framework

This study is guided by the Agronomic principles for good crop husbandry. The agronomic principles have been explained by [15] as the ways and means for the better management of the soil, plants and the environment for economically maximum returns per unit area. The agronomic practices that have been tested and proved to yield optimum results are often transmitted through agricultural extension systems, in the form of information-inputs or agronomic recommendations, to practising farmers. The information-inputs developed for the management of coffee [1] serve as the input variables or explanatory variables in this study.

1.6 Variables in the Study

(i) Explanatory Variables

The explanatory variables for the study are the information inputs possessed by the smallholder farmers regarding coffee agronomic practices. The use of specific information by the farmer, for purposes of coffee production, is regarded as information-inputs into the production system. It is recognized in this study that information is an important factor, just like land, capital and labour in any agricultural production system. The information is regarded as a non-physical input into the farm; used for purposes of carrying out appropriate farm practices. The information-inputs are in six thematic areas; cultivation practices (CP), soil fertility management (SFM), intensive land utilization practices (ILUP), crop protection practices (CPP), canopy management practices (CMP) and cherry harvesting practices (CHP). These variables were measured on a five-point scale based on the farmers' self-reported score (from 1 –Never to 5-Always used). The level of use of the information was in regard to its use for carrying out the scientifically and technically recommended best practices in coffee production. In this study a report of “never” means non-utilization of the information-input, either due to lack of the information or due to other personal constraints; because, whichever way, that information was not used in that farm.

(a) Information inputs on Cultivation practices: Farmers' information inputs on cultivation practices (CP) were expected to influence the productivity of coffee plants. Information on good cultivation practices maintain the recommended spacing between plants, provide for hand-weeding and herbicide use in integrated weed management. Good cultivation practices also provide mulch and irrigation as recommended by the ministry of agriculture [16]. The practice of mulching in perennial crops is widely viewed as beneficial to crop productivity due to its indirect effects on the crop. The use of information-inputs on mulching the soils with plant residues moderates the soil temperatures and conserves the soil moisture [17]. This function is desirable, particularly during the drought period in the areas west of the rift in Kenya. The organic residues that are applied as mulches will also act as a storehouse of nutrients and food for micro-organisms leading to mineralisation and the release of Nitrogen,

Phosphorous and Potassium which adds to the pool of readily available plant nutrients in the soil [15]. These processes contribute to enhanced crop productivity. The establishment of trees to provide shades to coffee trees and cultivation by forking at periodic intervals to break soil crusts are also important information-inputs for good cultivation practices [1].

Information on appropriate tillage practices leads to better tillage that influences the aeration and water retention in the soil and the root-spread and penetration and therefore the uptake and supply of nutrients to the roots of the plants [18]. The cultivation to incorporate other crops creates large pore spaces in the soil which enhances the interchange of soil carbon-dioxide and atmospheric oxygen for normal root development and microbial activities. This is particularly important for heavy clay soils [18]. A high concentration of carbon-dioxide in the root zone is toxic to plants. At concentrations as high as 10-20% in the root zones, the gas becomes toxic to the roots of most plant species. The high partial pressures of carbon-dioxide result in reduced root growth and inadequate absorption of nutrients [18]. Tillage is credited with the reduction in bulk density of the soils. A bulk density of about 1.1 grams per cubic metre contains sufficient pores to supply oxygen and water, but above 1.5 there is too little pore volume for air and water [18]. When these benefits of tillage are taken into consideration it becomes evident that information on the practice of forking has an important role to play in the productivity of coffee trees. The use of this information in the farmers' practices was measured on a ranking scale based on the farmers' self-reported evaluation. A five-point scale was used to rate the extent to which the information-inputs were used by the farmers in their practice; ranging from one (never used) to five (always used).

(b) Information inputs on soil fertility management practices: This category of information-inputs included the need for annual application of manure, periodic application of inorganic NPK fertilizer and the seasonal application of top-dressing Nitrogenous fertilizers. Each of these information-input indicators was measured on a ranking scale from 1 to 5 as evaluated by the respondent. Author [19] observed that Kenya's smallholder coffee production varies widely regarding the extent to which conventional technologies such as soil fertility management and crop protection are adopted leading to variation in crop yields. The applications of organic matter and NPK fertilizers annually have implications on soil health. The role of organic matter in crop productivity is widely acknowledged. Among its many functions, organic manures increase ped-formation (granulation), thus improving soil structure. Peds more uniformly surround each root to supply more air, water and nutrients compared to clods. The soil structural units are groups of soil particles held together by humus, Iron or gypsum. These natural structural units (peds) are more stable compared to the anthropogenic-formed clods [18]. The NPK fertilizers supply the nutrients required by plants in large quantities for their normal functions. When Nitrogen is a limiting factor the rate and extent of protein synthesis are depressed and plant growth is affected. Phosphorus plays an important role in energy metabolism and stimulates root growth, while potassium activates several plant enzymes in protein and carbohydrate synthesis [17]. Potassium also imparts resistance to plants against fungal and bacterial diseases among other functions in plants [17]. The adoption of the recommended practice of replenishing these nutrients annually is widely varied among small scale coffee producers in Kenya [19] and probably may be linked to information-inputs. Could this observation be linked to information-inputs? The current study investigates.

(c) Intensive land utilization practices (ILUP): This variable includes information on intercropping of young coffee plants with beans, Irish potatoes and vegetables.

(d) Canopy management Practices (CMP): This includes information on the annual pruning immediately after a major harvest every year and the periodic de-suckering every 2 to 4 months for purposes of maintaining an appropriate productive canopy.

(e) Crop protection practices (CPP): includes information on the integrated pest management practices such as pesticide application when necessary, use of appropriate protective clothing when applying the pesticides and the safe disposal of pesticide containers.

(f) Cherry harvesting practices (CHP): This includes the practice of picking red-ripe cherries during harvesting and the sorting of the cherry before delivering to the pulping factory. Information levels on these practices were measured on a five-point ranking scale from one (never used) to five (always used).

(ii) Outcome variables: The information-inputs on good agricultural practices were expected to result in higher crop productivity as measured by the quantity of cherry harvested per tree per year and its quality. The yields and the quality of coffee cherries harvested were used as indicators for productivity. The yield variable was measured on a continuous scale based on the respondents' records on yields for the crop harvested in the year 2020/2021. Quality was measured on an interval scale based on the farmers' assessment of the quality of cherries, from low represented by a rank of 1 to the highest score of 10. For purposes of statistical analysis this measurement was treated as interval scale variable.

Explanatory Variables

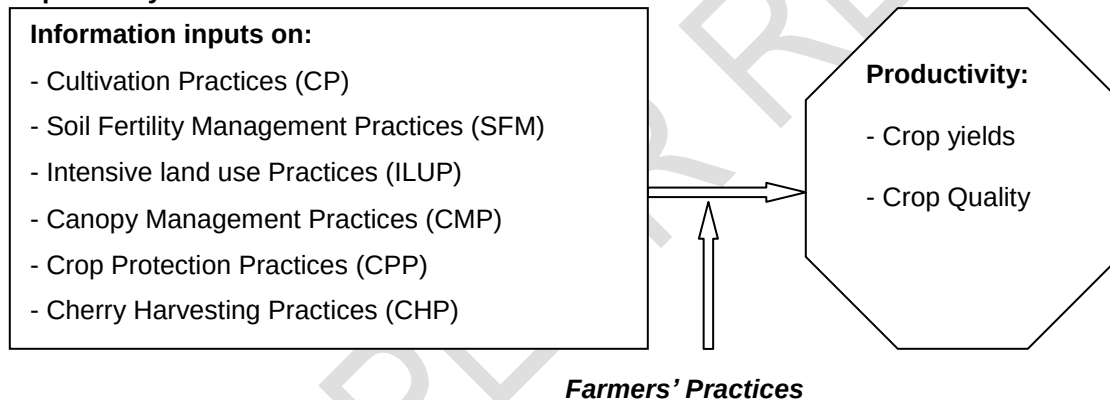


Fig. 4. Schematic illustration of the theoretical framework

2. METHODOLOGY

2.1 Study Site

The study was carried out in two counties located to the west of Rift in Kenya, namely; Kericho and Nandi counties. The two were selected based on the concentration of coffee farming in their localities as compared to other counties in the region to the west of the Rift in Kenya. The two counties share boundaries (Figure 1) and are located in the Rift valley region.



Fig. 5. Map showing the location of the area of study
(Source: Primary map from Google Earth, 2021)

2.2 Study Design

The study adopted an ex post facto survey design to gather data from smallholder coffee farmers in two sub-counties. The design allows for grouping of the subjects based on a prior characteristic they have. Two Sub counties were purposively selected for the study based on the intensity of coffee farming as compared to others within the region. Stratified random sampling techniques were used to select the participants. The sampling technique involves the classification of the N units of the population into a certain number of non-overlapping groups or strata [20]. The advantage of this technique is that it facilitates the subdivision of a heterogeneous population into smaller more homogeneous groups which have minimum variability within. Stratification in the current study was based on the farmers' cooperative society to which a farmer was affiliated. The farmers' cooperative societies are responsible for the provision of inputs in form of credits, coffee pulping facilities and marketing of farmers' produce. The different farmers' cooperative societies were therefore expected to influence the farmers' practices differently. Simple random sampling was used to select 10% of the farmers to participate in the study.

The stratified random sampling techniques were deployed to select participants for the study in the two sub-counties. From the two sub-counties of Kipkelion and Tinderet in Kericho and Nandi counties respectively, a list of Farmers Cooperative Societies (FCS) was used to select the Farmers Cooperative Societies to participate in the study based on their geographical distribution. From a total of 12 active farmers' cooperative societies in Tinderet, 4 were selected to participate and from a total of 15 FCS in Kipkelion, 5 participated in the study. From each participating FCS, a random sample of 10% of the small scale coffee producers was selected to participate in the study as suggested by [21]. Based on this sampling technique, a total of 140 smallholder coffee farmers were selected to provide the requisite data.

2.3 Data Collection Tools

The data were collected through the administration of a semi-structured interview schedule. The interview schedule was administered by enumerators who had been trained. The use of the interview schedule, as suggested by [22] requires that the enumerators be skilled and possess the capacity of cross-examination in order to find out the truth. The process of enumeration requires honesty, sincerity, patience and perseverance. In the current study, the enumerators were taken through the interview schedule so that they could well understand the implications of every question as suggested by [22]. Emphasis was made on the need for creating rapport with the respondents and exercising patience during the interview with a view to eliciting honest, truthful responses. This approach was used in order to generate reliable results. The enumerators were trained to use observation methods to cross-check the data provided by the respondents. All the enumerators recruited had certificate training in Agriculture and therefore could easily understand the content of the schedules, the importance of each item in the schedule and the need for truthful responses that are reliable.

Reliability has been explained by [20] to mean that there should be consistency in the results. According to [21], reliability is compromised by errors due to inaccuracy in scoring by the enumerator and inaccuracy of the instrument. To test the reliability of the instrument, a test-retest pilot survey was conducted. The test-retest survey involved administering the same instrument twice to the same group at a two-week interval and correlating the scores for the main items in the interview schedule. A coefficient of reliability of 0.85 was obtained suggesting that the instrument was reliable [21].

2.4 Data Analysis

The ordinal data obtained from the interview schedules were further converted into broader categories to facilitate robust analysis. An average score measuring the specific concept was obtained by summing up the values for each respondent and dividing by the total possible sum. This procedure produced a mean score less than 5 for each individual respondent for each of the six information-inputs on Good Agricultural Practices investigated; CP, SFM, ILUP, CMP, CPP and CHP. The averages generated were re-categorised into low (up to 3), medium (over 3 to 4) and high (over 4 to 5). The resultant categories represented low, medium and high levels of information inputs on Good Agricultural Practices respectively. Datasets on the outcome variable were similarly collapsed into low, medium and high for purposes of creating cross-tabulations with adequate number of items in each cell to suit the use of Chi square in the testing for ordinal level associations. Yield values below the mean were categorized as low; mean values as medium and above the mean as high. Associations between the information-input levels and the productivity levels were estimated using Chi squares' Contingency coefficient, C , as worked out from the formula:

$$C = \frac{\sqrt{\chi^2}}{N + \chi^2}, \text{ where } N \text{ is the sample size and } \chi \text{ is the Chi square value.}$$

Analysis of Variance (ANOVA) was run to establish whether there were significant differences between the categories on their coffee yields (kg/tree) and quality of produce. Differences that were flagged as significant by the tests were subjected to the Games-Howell post hoc test to determine where the differences were. The strength of effects was analysed by use of Eta squared coefficient (η^2), derived from the formula:

$$\eta^2 = \frac{SS_{\text{effect}}}{SS_{\text{total}}} \text{ where } SS_{\text{effect}} = \text{sum of squares for the treatment effect and } SS_{\text{total}} \text{ is the total sum of squares from the ANOVA. Eta squared } (\eta^2) \text{ has been explained by [23] as a measure of the proportion of variation in a dependent variable that is associated with membership of the different treatment groups. The interpretation for the magnitude of the effect was done as}$$

suggested by Cohen (1988) as cited by [23] where Eta squared values less than 0.06 are regarded as small, 0.06 to 0.14 as medium and above 0.14 as large.

3. RESULTS AND DISCUSSION

3.1 Demographics

Among the interviewees, 67.8% were males and 32.2% were females. The mean age for the respondents was 43 years with the youngest at 21 years and the oldest at 78 years of age. Majority of them had primary school level education (39.4%). Others had secondary level education ((32.2%), college and university education (25.6%) and 2.8% did not have any formal education.

3.2 Level of Information-inputs on Coffee Agronomic Best-Practices

The levels of information-inputs on agronomic practices were categorized into three based on the self-assessment report by the smallholder farmers. Their self-declared level of information use for the practice was categorized into low, medium and high, except for cherry harvesting which was categorized into low and high (Table 1). The categorization score was a composite score from a number of related agronomic practices each with a maximum score of 5 and a minimum of 1. A mean score of 3 & below was treated as low, above 3 to 4, medium and above 4, high as captured in Table 2. These scores can be regarded as self-declared levels of information-inputs on a given agronomic practice or put differently the extent to which farmers are informed about the practice and implement it. This was treated as such since the questions asked solicited the extent to which information on a given practice was put to use. Respondents who indicated that they did not even know about the existence of such information were readily coded as “never” used. Others who had the information indicated the extent to which they put it to use (score 2 to 4) and if they consistently used the information, coded “always” used (score 5).

The results suggest that majority of the farmers are conversant and implement cherry harvesting best practices well as evidenced by a high mean score (4.74). Canopy management practices was equally adhered to by the smallholder coffee farmers (4.36) as shown in Table 2. Little emphasis was laid on the information on intensive utilization of land (mean score of 2.82) probably due to a feeling that there is no severe shortage of land in the areas studied.

Table 2. Level of information-inputs per practice (N=140)

Perceived level of information inputs on:	Mean score	Frequencies		
		Low	Medium	High
Cultivation practices	3.79	17	72	51
Soil fertility management	3.95	24	49	67
Intensive Land use practices	2.82	87	34	19
Canopy management practices	4.36	19	34	87
Crop protection practices	3.88	30	54	55
Cherry harvesting practices	4.74	28	N/A	112

N/A = Not applicable since only two categories were derived from the primary data.

(ii) The Sway of Farmers' Information-inputs on Coffee Productivity

The outcome variable, yield, was measured on a ratio scale as Kgs of cherry per tree and also converted into an ordinal scale of low medium and high. Cherry yields less than 2 kg per tree were treated as low, above 2 to 3 as medium and above 3, high. Their frequencies were as indicated in Table 3. Quality was measured as interval data based on self-reported

ranks on a scale of 1 to 10. Disaggregation was done for the quality measures into three categories; 5 & below – ‘low’, over 5 - below 8 - ‘medium’ and over 8 – 10 as ‘high’.

Table 3. Productivity levels based on yields and quality (N=180)

Variable	Low	Medium	High
Yields	51	39	50
Quality	28	44	68

Cultivation practice information-inputs

The perceived level of information on best cultivation practices among the smallholder coffee farmers showed some association with yields as estimated by Chi square contingency coefficient ($C = 0.226$). This was a moderate strength of association [24]. It had a statistically significant association with the quality of cherries as reported by the respondents ($C=.305$, $P = .028$). It had no significant influence on both yield and quality when subjected to Analysis of Variance (Welch $P > .05$). Some relationship at the ordinal level suggests that the categorization into yield levels was effective. This indicates that low levels of information-inputs increase the chances of a farmer falling into a lower cherry-yield category. This observation is of value in the delivery of Agricultural information-inputs to the smallholder farmers. It implies that scientific and technological information delivered to the farmers will have positive consequences on coffee yields.

Soil fertility management information-inputs

Farmers’ perceived level of information-inputs on best practices in soil fertility management had a significant association with yields ($C = 0.373$). A contingency coefficient of 37.3% is regarded as moderately strong association in accordance with Cohen (1988) classification as cited by [24] as captured in Table 6. This suggests that the farmers’ yield is contingent on their perceived information-input levels on the practice.

Analysis of variance test was conducted to determine whether there were significant differences between the three group means with respect to their yields. A test for homogeneity of variance using Levene’s test confirmed that the distribution of cherry yields violated homogeneity of variance assumption ($P = .021$). Due to this violation a standard ANOVA could not be used but instead Welch ANOVA was run to test for mean differences among the groups. The advantage of the Welch’s ANOVA is that it can be used even when groups have unequal variance as it is non-sensitive to unequal variance situation (Liu, 2015 as cited by [25]). There was a statistically significant difference among the groups based on their perceptions on the level of use of information on best practices in soil fertility management (Welch $F(2, 65.987) = 16.501$, $P = .000$). A post hoc test was performed using Games-Howell. The post hoc test to establish where the differences were, revealed that there was a significant difference between the ‘low’ category with the other two ($P = .000$ between low and medium, $P = .002$ between low and high) as reported in Table 4.

Table 4: Comparison of yields between information-input levels

Information levels	Low	Medium	High
Low	X	- 1.88*	-1.26*
Medium	X	X	0.62 ^{NS}
High	X	X	X

Source: Field data, 2022

There was a mean difference of 1.88 Kg of Cherry per tree between those who perceived themselves as ‘low’ with regard to information-input levels on soil fertility management practices and this difference was highly significant ($P < .001$). There was also a significant difference with those who perceived their practices ‘highly’, with a mean difference of about

1.26 Kg cherry per tree ($P = .002$). The differences between 'medium' practitioners and 'high' was not statistically significant as illustrated in Figure 6.

This finding is consistent with the argument by [26] that most farmers are concerned with scientific and technological information for putting into practice in agricultural production. Their study showed that farmers' information needs were dominated by science and technology information needs for production at 50% of all their information requirements. Farmers' information on soil fertility management is expected to boost coffee production when appropriately used. Author [27], reported increased use of a recommended fertilizer in Kenya following exposure to information during a field day. It is plausible that such links between information and fertilizer use is expected to lead to higher productivity. A research conducted by [28], found that nutrient-inputs can boost productivity and quality of coffee when used appropriately. The appropriate use of nutrient-inputs however is arguably a product of being informed. Authors [29], while studying a similar, but slightly different concept of information literacy, reported a link between information literacy and the productivity of smallholder horticulture.

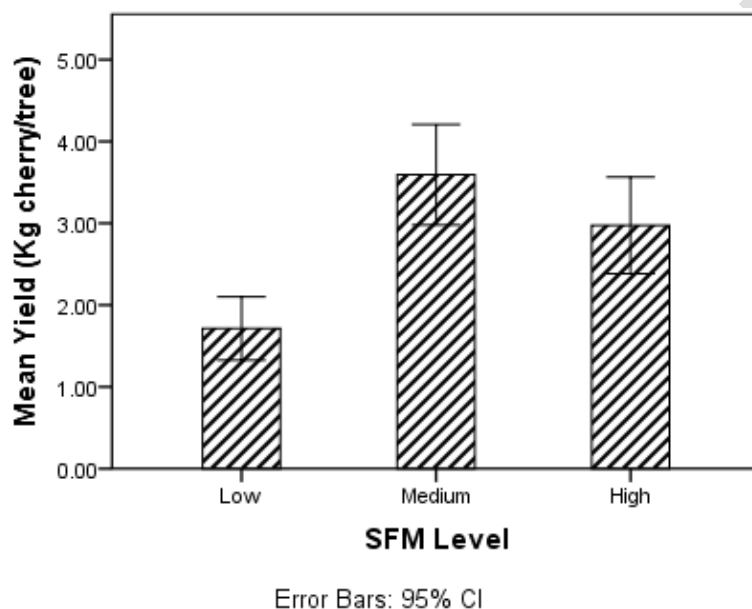


Fig. 6. Yield differences based on information-input levels on soil fertility management (Source: Field data, 2021)

Intensive land use information-inputs

There was a weak association between the perceived use of information on intensive land use practices with cherry yields ($C=.184$) and quality levels ($C=.120$) as indicated in Table 5. According to Cohen (1988) as cited by [24], however, this association cannot be ignored. Levels of information-inputs in this area of practice have some predictive value on the productivity of coffee. This observation has some backing from agronomic theory that suggests an improvement in soil health through intensive land use practices such as in the use of appropriate intercropping [18]. Farmers with satisfactory information-inputs on intensive land use practices are expected to report better overall crop yields and quality, partly due to an improved agro-ecology [18].

Canopy management information-inputs

The perceived level of application of information on canopy management best-practices had some moderate relationship with cherry yields ($C = .236$). Its association with cherry quality was moderate and statistically significant ($C = .289$, $P = .047$) as captured in Table 5. The statistically significant moderate strength relationship suggests that intensive pruning as practiced by the farmers based on their information levels resulted in higher quality of the cherries. This observation has implications in the planning of coffee extension packages. Further tests using Welch ANOVA showed a significant influence of the practice on quality (Welch $F(2, 35.096) = 6.562$, $P = .004$), but none on yield ($P > .05$). This observation seems to indicate that technical information on canopy management is critical to ensuring that smallholder farmers' coffee cherries are of high quality.

Crop protection information-inputs

The perceived level of information inputs on the adherence to crop protection best-practices showed a negligible association with cherry yields ($C = .108$), but a moderate strength association with quality of cherries ($C = .274$). There were no significant differences on yields and quality on Welch ANOVA ($P > .05$). The moderate level of association with quality of cherries implies that information on crop protection practices has some direct bearing on the quality of cherries ultimately delivered to pulping factories. Comments received by the farmers during the interviews suggest that the farmers who practised crop protection mostly grew traditional varieties such as K7 and SL28 that were less resistant to common diseases. Other farmers who grew recently developed varieties that are resistant to fungal diseases; Batian and Ruiru 11, as expected did not engage much on crop protection practices.

Cherry harvesting information-inputs

The perceived levels of information-inputs on the adherence to best practices in cherry harvesting did not show any association with yields ($C = .040$). It, however, showed a moderate strength of association with cherry quality as measured by Cramer's V coefficient ($V = .280$, $P = .015$). This observation of moderate strength relationship is logical, since it is expected that selective picking and sorting ought to improve the quality of what is being sorted; the cherries. A standard parametric test could not be performed since Levene's test indicated that the requirement of equality of variances had been violated ($P = .012$). A Welch ANOVA was conducted and this revealed the mean differences were not significant ($P > .05$).

Table 5. Correlations between information-inputs and productivity indicators

Information inputs area	Coefficient (C)	Coefficient (C)
	Yield	Quality
CP	.226	.305* ($P = .028$)
SFM	.373* ($P = .002$)	.023
ILUP	.184	.120
CMP	.236	.289* ($P = .047$)
CPP	.108	.274
CHP	.040	.280* ($P = .015$)

* Significant at .05 level of significance

CP-cultivation practice, SFM-Soil fertility management, ILUP – Intensive land use practice, CMP – Canopy management practice, CPP – Crop protection practice, CHP – Cherry harvesting practice

Table 6. Description of strengths of Contingency coefficients

Values	Qualitative description
Under .10	Negligible
.10 to under .20	Weak
.20 to under .40	Moderate
.50 to under .60	Relatively strong
.60 to under .80	Strong
.80 to 1.00	Very strong

(Source: Kotrlík, Williams & Jabor, 2011)

Effect sizes of information-inputs on yields and quality

An analysis based on Eta squared (η^2) indicated that soil fertility management had a medium size effect on cherry yields (Table 7). About 10.8% of the variation on cherry yields could be explained by the farmers' level of information inputs on soil fertility management. This finding suggests that the first need of farmers is to have relevant information to boost their productivity. Best practices in canopy management could explain about 7.8% of the variation in quality of the cherries. Other best-practices had small or negligible effect sizes on yields and quality (Table 7). Authors [4] reported that yields increased with intensity of management. The current finding is consistent with this argument since management implies putting technical information into use; the current argument is that effective management must be preceded by information-inputs.

Table 7. Effects of information-inputs on yields and quality based on Eta squared

Practice	Yields			Quality		
	Eta	(Eta) ²	Size	Eta	(Eta) ²	Size
CP	.151	.023	Small	.133	.018	Small
SFM	.329	.108	Medium	.163	.027	Small
ILUP	.138	.019	Small	.021	.000	None
CMP	.118	.014	Small	.280	.078	Medium
CPP	.099	.010	Small	.181	.033	Small
CHP	.009	.000	None	.061	.004	None

4. CONCLUSIONS AND RECOMMENDATIONS

The packages of information-inputs that are technically sound are held by smallholder farmers at different levels. The conversion of the information-inputs into agronomic practices has positive consequences on coffee yields and quality. The information-inputs, particularly on soil fertility management have a direct positive impact on coffee yields and coffee quality. The information-inputs on canopy management similarly have a direct impact on the quality of the coffee cherries in the study area. Based on these observations, it is recommended that the delivery of information inputs through coffee extension system should lay emphasis on soil fertility management and canopy management as a strategy for accelerated coffee productivity enhancement. There is a greater loss in yield where information levels on soil fertility management are low. Further study to unearth the latent facts for the differentiated information-input levels is recommended.

CONSENT

Consent was sought from individual respondents before data collection.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

FCS	Farmers Cooperative Society
ANOVA	Analysis of Variance