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Analysis of Institutional Factors Affecting Optimization of Coffee Yields in Chuka Sub-County, Tharaka-Nithi County, Kenya

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Authors' contributions

This work was carried out in collaboration between both authors. Authors DMK and GKG designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The importance of coffee production in the world economy cannot be ruled out due to its contribution in the developing countries in areas such as creation of employment and rise in foreign exchange. Most of the coffee producing countries in the world have come up with strategies to increase their quantity and improve the quality of their produce. In Kenya, the government have also come with numerous policies to support coffee production at the farm level but production of coffee in Kenya has since 1989 crop year been declining. There has been emergence of other enterprises that are profitable than coffee production such as real estate and dairy sector in most of the coffee-growing zones, but there are many farmers who have been determined to maintain coffee production. Despite the efforts made by the government to maximise coffee production in terms of quality and quantity, production has shown a downward trend, with some farmers completely doing away with production This study was aimed at assessing the factors that affect optimization of coffee production in Chuka sub-County, Tharaka-Nithi County. Proportional stratified random sampling was used to select a sample of 153 respondents from a population of 7,428 small-scale coffee farmers

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from ten cooperatives in the sub-County. The findings of the study indicated that access to extension, access to research and management of coffee cooperative were essential in coffee production with a mean agreement of 58.33%. The research established that access to extension (5%) and management of cooperatives (5%) were statistically significant while access to research at (5%) was statistically insignificant. Similarly, access to extension services increased optimization by 91%, poor management of coffee cooperatives reduced production by 45.1%, while access to research increased coffee production by 51%. Therefore, it is important to ensure farmers access extension services, research and there is improved management of coffee cooperatives.

Keywords: Coffee; small-scale; management; extension; research; optimization of production.

1. INTRODUCTION

In most countries, coffee production is declining, with countries having a decline in production by 48,200 kg tons per year [1]. However, the crop remains extremely important to about 80 countries in the tropics, with about 125 million depending on coffee for their livelihoods in Africa, Asia, and Latin America. Coffee Arabica (*Coffea arabica* L) and Robusta (*C. canephora* Pierre) are the two most economically essential in Africa, Asia, and Latin America to produce coffee beverages. Coffee genetic production is being lost rapidly due to numerous challenges such as land degradation leading to reduced farm size, human pressure resulting in the conversion of more land for settlement previously on agriculture, and low coffee prices resulting in the abandonment of coffee bushes. Similarly, the livelihood of many countries growing coffee is affected by changing climate that leads to a higher incidence of drought, increased incidence of disease, and pest and unpredictable rainfall patterns. The world has experienced changes in coffee production economics in recent years with increased costs of inputs and declining international world prices. The demand for specialty coffee is at an all-time high in the international market, and the farmers should concentrate on improving the quality of the crop to meet the demand. The final quality and taste of coffee are determined by the coffee varieties that are adapted to the different growing regions.

A study by Nghiem et al. [2] reported that coffee is among the most marketable trade agricultural product accounting for export amounting to about 17.1 billion US dollars in 2015/2016. South American, Asian, and African countries are the leading coffee producers in the world. Brazil, Colombia, Indonesia, and Vietnam are the leading coffee producers globally, accounting for more than 30 percent. However, when people in Africa talk about coffee production in the world, many think of Brazil, but Uganda and Ethiopia are also among the 10 top coffee producers. According to Harrison et al. [3] these countries use coffee as an essential source of national income for the government and the rural population. In addition, other countries in African countries producing coffee include Tanzania, Cote d'Ivoire, Madagascar, and Kenya who export their coffee in raw, thereby fetching low prices.

In Kenya, coffee production provides a substantial income to farmers and foreign exchange to the government that is essential to improving living standards through increased GDP, tax generation, and job creation. Miito and Banadda [4] reported that only 2.5 percent of the coffee produced in the country is locally consumed despite the high tourist potential that should promote coffee value addition. Chuka's annual coffee production is about 600 kg per hectare which is lower as compared to potential production of 2,300 kg per hectare in other parts of world. According to Tadesse et al. [5], coffee production was ranked second after tea in 1989, but in recent years, the production has declined, and coffee yields are ranked fourth after horticulture, tea, and tourism subsectors. However, coffee contributes to approximately 10 percent of the total agricultural earning received exports and employs about 30 percent labor force. Kenya has high production and quality potential, but the country is faced by low coffee yield due to lack of promotion for domestic consumption, low prices, massive worldwide overproduction in the 1990s crisis, strict rules prohibiting trade, inaccessible credit facilities, and uprooting of the coffee crop [6].

In Chuka, small-scale coffee production has come under numerous challenges associated with low productivity, reduction in area under coffee coverage, reduced general productivity, and low farmers' income. According to Tadesse et al. [5], the cooperatives in Chuka Sub-county collected about 88,000 kg of coffee, but only

11,000 kg were marketable due to the poor quality of the cherry associated with disease and pest infection. The crop's poor performance has affected the economy of the farmers' area and income in the Chuka Sub-county. Nevertheless, coffee production remains one of the significant agricultural products in the provision of livelihoods for the farmers in Chuka Sub-county. There have been efforts by different key players to improve coffee production and quality, though general production continues to decline, with the majority of farmers abandoning production of the crop. The farmers who are abandoning coffee production have turned to other sectors such as construction and building, dairy farming, and tea production. Deserting the coffee sector through uprooting and abandoning will have severe consequences on the livelihood and economy of Chuka Sub-county. Different scholars have researched factors such as cost of production and marketing interventions in the Chuka Sub-county, but limited studies have focused on the institutional factors affecting the optimization of coffee production. This study aimed to assess the effect of lack of access to extension, lack of access to research, and poor coffee cooperative management.

2. METHODOLOGY

2.1 Study Area

Chuka Sub-county in Tharaka Nithi County, Kenya, was the site of the study. The study was conducted in three wards, namely, Karingani, Mugwe, and Magumoni, which covers a total area of 308 km^2. Rithaa and Mugambi [7] stated that area comprises and multiplicity physical of topographical factors whose interaction results in average climate conditions. The factors include altitude, prevailing winds, latitude, and vegetable cover. The annual rainfall ranges between 1200 mm and 2200 mm, and the annual temperature range between 14 ^0C and 30 ^0C, which is suitable for coffee production. Similarly, Chuka Sub-county is characterised by aspect of constant radiation surplus climate. The soils in Chuka Sub-county are influenced by silandic volcanic soil around Mt Kenya, which are well-weathered, deep, well-drained, and moderate to high fertility.

2.2 Research Design

A descriptive survey design was used by the study targeting small-scale coffee farmers in Chuka Sub-county. Descriptive research gives a description of the present state of affairs as they exist [8]. The descriptive survey design used accommodated for collection of qualitative data. Furthermore, the design was essential in giving an in-depth understanding of the research problem within a short time without manipulating research parameters. The design was also appropriate in describing the characteristics of the entire coffee farmers in Chuka Sub-county. The study used both secondary and primary data where secondary data was obtained from journals, and primary data was collected through structured interviews and questionnaires. The questionnaires were administered to the coffee farmers in different coffee cooperatives while structured interviews were administered to different officials such as managers, treasurers, and secretaries of coffee cooperatives and officials in the ministry of agriculture in Chuka Sub-county. The questionnaires sought to establish whether the coffee farmers had access to extension, access to research, and how cooperatives were managed.

2.3 Sample Size and Sampling

The total population of coffee farmers in Chuka Sub-County is 7,428. The study applied proportional stratified random sampling to select a sample of 153 coffee farmers, where each coffee cooperative was treated as a stratum. Simple random sampling was used to select respondents from individual coffee cooperative (Rubate, Muiru, Kabuboni, Kiangondu Gitareni, Kirubia, Magumoni, Mwangu, Thuita, and Ndagani,) in Chuka Sub-county as the farmers were mutually homogeneous. The study applied Slovin's formula to establish the sample size from the coffee farmers' strata.

$$n= N\div[1+N(e)^2]$$

Where; n= sample size N= Population size, e= level of significance

$$n= 7{,}428\div [1+ 7{,}428(0.08)^2] = 153$$

2.4 Data Collection

The questionnaires and structured interview applied captured different institutional factors affecting coffee production optimization in the study area. The institutional factors affecting optimal coffee production were addressed in the questionnaire and the structured interviews. The

questions in the questionnaire were divided into three sections (A, B, and C). Section A covered question concerning access to extension; section B was questioned about access to research, while section C was about coffee management, affecting coffee production optimization. The study visited Sub-county Agricultural Extension Officer in study area to ascertain validity. Similarly, Cronbach Alpha was calculated where a value of 0.802 was obtained indicating the items in the questionnaire were worthy. The study followed the three important principles of the fundamental assumption of ethics, which include respect, fidelity, and confidentiality. In this regard, all data collected was used solely for this proposed study with no reference to individuals. All secondary data sources were acknowledged and cited in the report.

2.5 Data Analysis

Statistical Package for Social Science (SPSS) version 25 was used to analyze the data collected. Descriptive statistics such as frequencies, percentages, and means were used to provide interpretation for analyzed data. The study applied the logit model to analyze binary data.

$$\text{n}\Omega_{y\leq m}(x) = \tau_m - x\beta$$

Where,

$$\Omega_{y\leq m}(x) = \frac{pr[y\leq m\text{Ix}]}{pr[y>m\text{Ix}]} \quad 3.1$$

The logit model can take the following form:

$$p(y = 1\text{Ix}) = \text{p}(\text{y} = 1\text{I}X_1, X_2 \ldots \ldots X_k) \quad 3.2$$

Where x denotes a full set of the explanatory variable

$$y = \begin{cases} 1, & \text{if the coffee production is optimized} \\ 0, & \text{if the coffee production is not optimized} \end{cases}$$

The fitted probabilities can have the disadvantage of producing values that are less than zero or greater than one. Limitation of variables was avoided by the introduction of a class of binary response models was formed as follows:

$$p(y = 1\text{Ix}) = \text{G}(\beta_0 + \beta_1 x_1 + \cdots \ldots \ldots B_K X_K) = G(\beta_0 + \text{x}\beta) \quad 3.3$$

Where; G is the logistic function taking on values strictly between zero and one: $0 < G(z) < 1$

$$G(z) = \frac{\exp(z)}{[1+\exp(z)]} = \wedge(z) \quad 3.4$$

$$x\beta = \beta_1 X_1 + \cdots + \beta_k X_k \quad 3.5$$

The percent correctly predicted measure of fit was computed to establish the goodness of fit of response. The percent correctly predicted probability was computed as follows: for each i computed, it was estimated that the probability that y_i takes on the value one, $G(\beta_0 + x_i\beta)$. If $G(\beta_0 + x_i\beta)$>0.5, the prediction of y_i is unity, and if $G(\beta_0 + x_i\beta) \leq 0.5$ y_i is predicted to be zero.

$$\hat{y}_1 = \begin{cases} 1\text{if } \hat{y}_1 > 0.5 \\ 0 \text{ if } \hat{y}_1 \leq 0.5 \end{cases} \quad 3.6$$

3. RESULTS AND DISCUSSION

The study focused on establishing the quantity of coffee that the respondents produced in kilograms for the last two crop years. The findings of this research indicated that the majority of the participants, at 50% produced between 300-399.9 kg in the crop year 2016/2017, and 47.9% of the respondents produced between 200-299.9 kg in crop year 2017/2018 against 2,300 kgs attained by other countries in the world. These findings indicate a decline in coffee production in 2018/2017 compared to 2016/2017 (Table 1). The effective flowering, the maturation, and the prevalence of diseases of coffee cherries is directly affected by rainfall distribution. Hence, coffee production has a high relationship with the patterns of rainfall distribution. The drought experienced during the 2017/2018 may have led to a reduction in coffee volumes. The study's findings concur with Singh [9], who reported low rainfall leads to stress in the coffee bush that is likely to lower the production and result in small-sized coffee beans. Similarly, changes in rainfall patterns affect the productivity of coffee, such that high rainfall affects flowering. The drought experienced in Chuka Sub-county in crop year 2017/2018 affected the overall coffee plant health leading to low production. The drought was also associated with poor farming practices such as labour efficiency, picking when the cherries were ripe, and fertilization regimen.

3.1 Access to Extension

The study aimed to determine the influence of access to extension among the respondents. The study sought to establish whether the respondents were aware of any specialized

extension officer in the study area, age, and diseases affecting coffee plants and the plant clinic's attendance. The role of extension officers is significant in the dissemination of information to farmers in any agricultural sector. The majority of the respondents at 90% indicated that they were not aware of extension officers who had specialized in coffee production, as most of them had general agricultural extension expertise while 10% were aware of the coffee specialist (Table 2). The respondents who were aware of a specialist indicated that the Centre for Agriculture and Bioscience International (CABI) was essential in providing coffee specialists. Also, the individual millers and the cooperatives provided extension services to the farmers in attempts to increase their competitiveness in Chuka Sub-county. The findings agreed with those of Okeke et al. [10], who reported that few of the farmers were aware of extension officers who had a specialization in particular crop management. This study's findings contradict Shemfe and Oladele [11] and Davis et al. [12], who stated that farmers were aware of different extension officers who had a specialization in various sectors such as coffee, tea, horticulture, and dairy sector.

The respondents were asked to specify the different diseases that were affecting the coffee, and 53.6% of the study participants reported that coffee berry disease (*Colletotrichum kahawae*) affected most farmers (Table 2). This study also sought to establish whether the respondents were attending plant clinics planned by the extension officers from Chuka Sub-county's Ministry of Agriculture. The findings showed that most study participants at 57.1% were not attending plant clinics to optimize coffee production against 42.9% who were attending (Table 2). This study's findings concur with those of Shemfe and Oladele [11], who reported that despite governments and other NGOs' efforts to introduce training to farmers, including plant clinics, the majority of the respondents did not attend. Most of the farmers established that the meetings were a waste of time as there were claims that some extension officers disseminated misleading and incorrect information to farmers. It was noted that remoteness of extension and failure by coffee farmers to attend plant clinics led to a high rate of disease invasion.

The study was to establish the importance of extension services to the coffee farmers. The respondents at 70% (Mean agreement of 3.5) agreed that extension services positively impacted coffee optimization (Table 3). The extension had a role of disseminating essential information to the coffee farmers.

Table 1. Coffee Production in Crop year 2016/2017 and 2017/2018

Quantity (kgs)	2016/2017		2017/2018	
	Frequency	Percentage	Frequency	Percentage
1-99.9	7	5	12	8.5
100-199.9	15	10.7	17	12.1
200-299.9	40	28.6	67	47.9
300-399.9	70	50	40	28.6
400 and above	8	5.7	4	2.9
Total	140	100	140	100

Table 2. Awareness of the existence of coffee specialist

Awareness of Existence	Frequency	Percentage
Yes	14	10
No	126	90
Total	140	100
Attending Plant Clinic	Frequency	Percentage
Yes	60	42.9
No	80	57.1
Total	140	100
Type of Disease	Frequency	Percentage
Colletotrichum kahawae	75	53.6
Hemileia vastatrix	42	30
Mycosphaerella coffeicola	16	11.4
Colletotrichum	7	5
Total	140	100

Table 3. Importance of extension visits in optimization of coffee production

Factor	N	Mean agreement	%	Standard deviation
Extension visits play a significant role in the optimization of coffee production	140	3.5	70	1.0489
Total		3.5	70	

3.2 Access to Coffee Research

The study was to determine whether the respondents in Chuka Sub-county had access to research in order to optimize their coffee production. The study determines awareness of research in the coffee sector, availability of new coffee cultivars, budgetary coffee allocation, and any change in coffee varieties for the last five years. The availability of research influences the availability of new coffee varieties that best adapt to the Chuka Sub-county and which resistant to diseases and are of high production and optimal performance. The majority of the study participants at 57.1%, reported that they were aware of research to improve coffee optimization in the area (Table 4). This study's findings contradict Suhartono and Widiyanto [13], who stated that most farmers are not involved in agriculture research. Lack of access to agricultural research affects productivity as limits factors such as new production techniques, new technology, and inputs to apply to improve agricultural production.

The findings of the study agree with Nghiem [2], who reported that 58% of the respondents were aware of research in different sectors as they play an essential role in active research. Well, a detailed agricultural research system transforms agriculture to achieve sustainable income among the small-scale farmers. Lack of defined priorities, low budgetary, and shortage of scientific and trained technical staff.

The research sought to establish whether the coffee farmers in Chuka Sub-county were aware of any funds allocated to coffee research in the area. The results indicated that most of the study participants at 92.9%, were aware of the funds set aside for the production and marketing processes against 7.1% (Table 4).

3.3 Coffee Cooperative Management

The study conducted was to establish the perception of coffee farmers on the coffee cooperatives' management in attempts to optimize production. This was to be achieved through establishing whether cooperatives offered salary advances, the mode of payment used by cooperatives, duration between the payments, and perception of how the cooperatives were managed. The majority of the study participants at 69.8% averagely agreed that the cooperatives were managed well (Table 5). Most of the respondents who indicated that they were well managed indicated that they acted as major credit sources for different needs of the coffee farmers. The cooperative societies' ability to offer credit to farmers resulted in a strategic alliance with the cooperative societies, which was essential in reducing farmers' search for loans from financial institutions. This study's results concur with Cam [14] and Maundu [15] findings' who reported that different farmers' cooperatives were well managed and provided the farmers with services such as extension, research, and credit services.

The findings of this research indicated that 48.6% of the respondents felt that the cooperatives were poorly managed. The respondents who felt that one society was poorly managed opted to shift to another society located in a different location, resulting in increased transportation cost, leading to the non-optimization of coffee production. This study's findings agree with those of Balgah [16], who

Table 4. Awareness of research of coffee production and budget for research

Research awareness in area	Frequency	Percentage
Yes	80	57.1
No	60	42.9
Total	140	100
Awareness of Budgetary allocation		
Yes	130	92.9
No	10	7.1
Total	140	100

stated that corruption and robbery of high-quality coffee make farmers perceive cooperatives as poorly managed. On the other hand, the findings of this study contradicted with Yen [17], who reported that the majority of the coffee cooperatives at 67.4%, were well managed, and they are vital in reinvesting the fee charged from the members in a collective manner.

This study also established that the coffee farmers who felt that the cooperative society was not well managed and owned over 1,500 coffee bushes could acquire permits for selling their coffee directly to millers from the Ministry of Agriculture. The study also sought to establish whether the coffee cooperatives were offering payout advances to farmers to meet their basic needs. The study observed that majority of research participants at 90% had access to payout advances against 10% who reported otherwise (Table 6). The study's findings are in agreement with Matusse [18], who reported that the Kenyan government had promised to offer credit to farmers that were equivalent to the annual earnings that would assist them in meeting their period financial needs.

The study also sought to establish the mode and duration of payment made by the cooperative societies to coffee farmers. The findings of this study established that 90% of the coffee farmers were paid through the banks, while 10% received their payment from the cooperative societies on a cash basis (Table 6). The study participants were asked to indicate the duration between which they had to wait for payment after delivering their produce to the factory. The findings of this study indicated that the cooperatives were paying twice a year (Table 7). The findings of this study were in agreement with Vishwanatha [19], who reported that coffee cooperatives pay their members twice as the crop is harvested twice in a year.

The findings of this study were against the findings of Okeke et al. [10] who reported that the cooperatives were paying the members once in a year. The study also sought to establish whether the coffee farmers were satisfied with the payment rate at which they were paid twice a year. 90% of the respondents indicated that they were not satisfied with the payment rate in which they had to wait twice a year (Table 7). On the other side, 10% of the respondents indicated that they were satisfied with the payment rate as it enabled them to save their money.

Table 5. Mean agreement on management of the cooperative societies

Factors	Mean agreement on likert scale of 1-5 points	Percentage	Std. deviation
Well managed	3.37	67.4	1.0617
Averagely managed	3.49	69.8	1.0086
Poorly managed	2.43	48.6	.9887
Total Mean	3.1	61.93	

Table 6. Provision of payout advance

Payout advance provision	Frequencies	Percentage
Yes	126	90
No	14	10
Total	140	100

Table 7. Mode of payment and duration by cooperative societies

Mode of payment	Frequencies	Percentage
Through the Bank	126	90
On Cash Basis	14	10
Total	140	100
Duration of Payment	N	Percentage
Every Month	0	0
Twice a Year	140	100
Once a Year	0	0
Total	140	100

The study was to establish the plans in place by the farmers who were not satisfied with the duration and rate of payment in made on their coffee could do with their coffee bush. The majority of the respondents at 50% reported that they had a plan of intercropping their bushes with various crops such as maize and bananas. 25% of the study participants noted that they had a plan of uprooting their coffee bushes while 21.4% of the respondents reported that they planned to reduce the piece of shamba allocated to coffee crop. Lastly, 3.6% of the respondents reported that they had other plans like abandoning their coffee bushes (Table 9).

Table 8. Satisfaction of coffee farmer on the mode of payment

Satisfaction on duration	Frequencies	Percentage
Yes	14	10
No	126	90
Total	140	100

The findings of this study concur with those of Okeke et al. [10] who noted that coffee farmers who are not satisfied with their farming venture opt for doing away with such ventures. The results of the study contradicted the findings of Agesa et al. [20] who noted that 67% of the farmers who takes a venture non-profitable goes for uprooting the coffee bush.

Table 9. What unsatisfied farmers plan to do

Type of cultivar	Frequency	Percentage
Uproot the Coffee	35	25
Intercrop the Coffee	70	50
Reduce Area Under Coffee	30	21.4
Others	5	3.6
Total	140	100

The increased uprooting and intercropping coffee have reduced the area used for coffee production in Chuka Sub-county with some farmers opting for more profitable economic activities such as dairy, tea, bananas and rental houses.

3.4 Mean Importance in a Scale of 1-5 of Extension, Research, and Cooperative Management

The study also determined the mean ranking of the essence of three institutional factors affecting coffee production optimization. The study established that extension, research, and cooperative management were vital to improving coffee production with a mean of 58.33%. However, the essence of the extension was ranked highest with a mean of 60.8%, research was ranked second with a mean score of 57.2%, while cooperative management was lowest with a mean score of 57% (Table 10).

The findings of the study concur with those of Rithaa and Mugambi [7] and Agesa et al. [20] who reported that farmers who had access to extension services had improved management skills of their farms. Furthermore, the study's findings agreed with Suhartono and Widiyanto [13] and Fackler and Weigt [21] who reported that agricultural research was transformative and helped farmers achieve sustainable income among farmers. The extension services are vital in the dissemination of information through practices such as plant clinics. The extension programs provided are essential in the reduction of poverty, boost productivity, increase farm revenue and minimize food insecurity.

3.5 Institutional Factors Affecting Optimization of Coffee Production

The study applied the logit regression model with the assistance of SPSS version 25. The dependent variable outcome was coded as "1" for high production (optimization of coffee production) and "0" for low coffee production (low coffee optimization). The research reported that 111 respondents had low production against 29 respondents with high production (Table 11).

Table 10. Mean importance in a scale of 1-5 of extension, research, and cooperative management

Factors	Mean importance on Likert scale of 1-5 points	Percentage	Std. deviation
Extension	3.04	60.8	1.0617
Research	2.86	57.2	1.0086
Cooperative	2.85	57	.9887
Total Mean	3.04	58.33	

Table 11 gave a description of the baseline model describing the explanatory variables. The overall percentage row at 79.3% demonstrated that the prediction approach was correct since it exceeds 50% (Table 11). The study also establishes that the model used was statistically significant since P<.001 (Table 12). Therefore, the model can be applied since it has high predictive power (the application of the model is better than just guessing).

The Omnibus Tests of Model Coefficients were applied to determine the difference between the model (with explanatory variable included) and the base baseline model. The model's chi-square value was 33.025, df=5, and p=0.000 (Table 13); therefore, the independent variable can significantly predict the explained variable since P value=0.000<0.5. The model also sought to compare if there was a significant difference in chi-square tests between -2LLs (Log-likelihoods) of the baseline and new model. The new model recorded a reduced chi-square -2LL value from 154.001 to 139.816 from the comparison of the baseline model; thus, the baseline model is an enhancement and describes more of the variance in the outcome.

Moreover, -2LL model value of 139.816 was used to compare the -2LL from the null model calculated in the omnibus test of model coefficient, which indicates a decrease in the -2LL of the new model (with explanatory variables). Hence, the new model is significantly fit as compared to the baseline model. The pseudo-R^2 value was also calculated to establish the variation in the outcome. The model explained the variation in the output roughly by 33%, which means that the variables could be used since the figure was above the threshold of 20% (Table 14).

Through the Hosmer & Lemeshow test of goodness, the model was a good fit for the collected data P value=0.795 which is > .05. The overall model was significant and fit, as indicated by the chi-square value (Table 15). The model indicated that access to extension service (5%), cooperative management (5%) was statistically significant, while access to research (5%) was statistically insignificant (Table 16). The effects of the independent variables used to estimate the logit regression were presented using coefficients and P-values signs of each dependent variable. This study's findings were consistent with Verbeeck [22] and Shemfe and Oladele [11] reported that access to extension and cooperative management has a positive and significant impact on the yield of coffee production. Both access to research and cooperative management affects the quality and quantity of coffee yield without interference from other factors.

The study implied that access to extension had a negative and significant (P= 0.012) effect on coffee production optimization. The findings of this study noted that access to extension services increases coffee optimization by 91% (Table 16). The findings of this study were in agreement with Amadi and Raji [23] who stated that extension services farmers in are essential in diffusion dissemination of knowledge among farmers. The information and knowledge disseminated by the extension services help farmers understand various optimization technologies and techniques. The study implied that cooperative coffee management had a negative and significant (P=0.002) effect on the optimization of coffee production. This study indicated that poor coffee cooperative societies' poor management is likely to reduce the optimization of coffee yields by 45.1 times. Cooperative societies are charged with the role of managing most activities at the farm level. Similarly, cooperatives play a vital role in offering extension services, farm inputs, and credits to farmers. Therefore, mismanagement of the coffee cooperative societies will halt services such as the supply of inputs, credit offers, and marketing of the coffee yields. This study's findings were in agreement with Nasr and Sewilam [24], who reported that cooperatives societies are essential in facilitating agricultural commodities' production and marketing. However, the study findings were against the results of Harrison et al. [3], who noted that many successful farmers are not members of any cooperative society.

The findings of this study indicated that access to research findings had negative and significant (p=0.001) on coffee production. The farmers who had access to research were 51% more likely to increase their coffee optimization (Table 16). The study noted that the farmers were not in a position to use the research findings as most of them could not read and interpret the different reports. Further, some of the research findings provided to farmers were not adequate to the area as they were suited to different ecological zones. The findings of this research concur with Warinda et al. [25], who argued that research

findings such different cultivars to be planted were suitable for the specific area. The low education level in Chuka Sub-County is one factor that reduces access to research findings as most of the information is presented in online or printed platforms. On the contrary, Fackler and Weigt [21] stated that most farmers had developed on-farm research that they conduct in groups to establish which varieties perform well in their region.

Table 11. The dependent variable encoding of outcomes

Encoding of outcomes					
			Predicted		
Observed			Coffee yield		Percentage correct
			high production	Low production	
Step 0	Coffee yield	High production	0	29	0.0
		Low production	0	111	100.0
	Overall Percentage				79.3

Table 12. Variables in the equation

Equation variables							
		B	SE.	Wald	Df	Sig.	Exp(B)
Step 0	Constant	1.342	0.209	41.424	1	0.000	3.828

Table 13. Omnibus tests of model coefficients

		Chi-square	Df	Sig.
Step 1	Step	33.025	5	0.000
	Block	33.025	5	0.000
	Model	33.025	5	0.000

Table 13. Model summary

-2 Log likelihood	Cox & snell R square	Nagelkerke R square
139.816[a]	0.21	0.33

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001

Table 14 Hosmer and lemeshow test

Step	Chi-square	Df	Sig.
1	36.881	7	0.795

Table 16. Variables in the equatiaon

		B	SE.	Wald	Df	Sig.	Exp(B)
Step 1[a]	Access to extension (1)	-0.100	0.714	0.020	1	0.012	0.905
	Access of research (1)	-0.667	0.449	2.209	1	0.001	0.513
	Cooperative Management	-0.372	0.431	0.746	1	0.002	1.451
	Constant	1.061	0.845	13.092	1	0.000	5.087

Number of obs=140, Wald chi2 (5) = 42.12, Prob> chi2= 0.0000, Log pseudo likelihood=-139.82, and Pseudo R^2 =0.33

a. Variable(s) entered on step 1: visit of extension, Management of coffee cooperatives, Access to research

4. CONCLUSION

There was a decline in coffee production from 2016/2017 to 2017/2018, which may be associated with a lack of extension, lack of research, and poor coffee production management. The importance of extension services cannot be underrated as it affects the quality and quantity of coffee to be produced. The availability, skills, and accessibility of extension work is vital in disseminating crucial information to the farmers that assist in introducing good agricultural practices. Similarly, the lack of research reduced the knowledge of varieties that would be planted to optimize coffee production. The cooperatives' ability to offer coffee farmers with farm inputs and credit services makes them essential in optimizing coffee production.

CONSENT

As per international standard or university standard, participant's written consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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