Determinants of Quantity of Mango Supply among Small-Scale Farmers in Machakos County, Kenya

Authors details

John Kennedy Musyoka
University of Embu, Department of Agricultural Economics and Extension
Po Box 6-60100, Embu
Telephone Contact: 0790344518
Email: musyoka.john@student.embuni.ac.ke
https://orcid.org/0000-0001-9344-0387.

Hezron Nyarindo Isaboke
University of Embu, Department of Agricultural Economics and Extension
Po Box 6-60100, Embu
Telephone Contact: 0705955732
Email: hisaboke@gmail.com
https://orcid.org/0000-0003-4952-8474.

Samuel Njiri Ndirangu
University of Embu, Department of Agricultural Economics and Extension
Po Box 6-60100, Embu
Telephone contact: 0723 987104
Email: ndirangu.samuel@embuni.ac.ke

Abstract

In Kenya, mango production is mainly practiced by small-scale farmers as a source of income, form of employment, food and nutrition. Farmers are able to produce more than the amount required to satisfy consumption at the household level. However, there exists a weak linkage with the markets, and thus the opportunity to diversify the farmers' livelihood from mango production is limited. This study was conducted to evaluate the factors influencing the quantity of mangoes supplied to the market among small-scale farmers in Machakos County, with the aim enhancing the farmers' market participation. Primary data was obtained using a semi-structured interview schedule. Two-stage sampling technique procedure was used to obtain a sample comprising 352 small-scale mango farmers. The two-stage least square regression model was used to determine the effect of selected factors on quantity supplied to the market. The results revealed that the quantity of mangoes produced, market prices, market access, extension contact, amount of credit accessed positively and significantly influenced the quantity of mangoes supplied. While the age of household head precipitated a negative effect on quantity supplied. Based on these findings, the researcher recommend enactment of appropriate policies by the policy makers to facilitate extension contact, access to credit and market outlets to enhance farmers' market participation.

Keywords: *Mango production, quantity supplied, market participation, two-stage least square regression.*

1. Introduction

Mango *(Mangifera indicia L.)* is the second most important fruit in the tropics and subtropics after banana. It is commercially grown in more than 90 countries worldwide and consumed in both fresh and processed forms (Mathooko *et al.*, 2013). India is the largest producer of mango, accounting for 50% of the global output. Kenya is among the leading producers of mangoes in Africa (United States Agency for International Development, 2018). Mango production targets fresh fruit markets and the processing industry. Additionally, its fruit flavor and high nutritional value have placed it in a higher popular position as a source of income to farmers, traders, and international markets (Rodriguez *et al.*, 2012). The quantity of agricultural produce supplied to market depedents on various activities along the value chain such as planning for the production, grading, transport, distribution, pricing, sending information from the farm to the market (Jemal *et al.*, 2019). Currently, most of the developing countries have sought to improve their production and marketing of agricultural produce to accelerate economic growth, create employment and alleviate poverty (Asfaw *et al.*, 2010; Jemal *et al.*, 2019). Small-scale farmers participation in marketing of their produce enables them to increase their household income and ability to purchase necessities in return (Schneider and Gugerty, 2010; Holzapfel *et al.*, 2014). However, in the absence of well-functioning markets, agricultural production can experience a lot of problems more so to the perishable horticultural produce like mango fruits (Kassa *et al.*, 2017).

Supply of agricultural produce to the market is usually thought to be only in large scale farming and economists tend to ignore the fact that small-scale farmers and poor farm households participate in the market either because they produce some surplus or sell to earn income for purchase of necessities (Martey *et al.*, 2012). In Kenya, brokers form the largest group of mango sellers and they operate majorly in an environment of uncertainty and avoid entering into formal contracts with the farmers. This creates fear among the farmers but still, they sell their products to them to avoid high transaction costs that are experienced along the marketing chain (Msabeni *et al.*, 2012). In the case where the markets have been subverted by brokers, farmers organize themselves into marketing groups or cooperatives to access the market. This gives them more bargaining power for their produce over brokers, who often manipulate and control the prices in the marketing system which in turn increases farmers' income as well as the quantity of produce supplied to the market (Shiferaw *et al.*, 2011; Panda and Sreekumar, 2012).

Diversification into horticultural produce is becoming more attractive to small-scale rural farmers across the globe. This is because the worldwide production of fruits has grown faster compared to cereal crops and the total value of the horticultural crops traded at

present is more than double that of cereals (Pingali, 2015; Mariyono, 2020). As a result of this, farmers involved in horticultural production usually earn much higher farm incomes as compared to cereal producers, and their per capita income is also five times higher than cereal producers (Ayalew, 2015). The Horticultural Crops Directorate (2018) has classified mango as a permanent horticultural crop which means it occupied the field for a long period and does not have to be replanted for several years after each harvest. Most permanent crops produced by smallholder farmers are marketed by the non-public entrepreneurs who operate in the marketing value chain and distributes the products to terminal markets (Kassa *et al.*, 2017). Thus, the marketing chains are well known, however, smallholders specifically face high costs in accessing markets, inadequate and uncoordinated crop market information systems.

In Kenya, the area under mango cultivation has been increasing over the years to 46,364 hectares in 2017 and 49,098 hectares in 2018 respectively (Horticultural Crop Directorate, 2018). Statistics show that mango cultivation contributes approximately 5% of the Agricultural Gross Domestic Products (GDP) and 2% of the national GDP, employing a considerable number of the seasonal labour force (Ministry of Agriculture Livestock and Fisheries, 2018). Literature shows that small-scale fruit farmers have been excluded from the marketing value chain due to lack of economies of scale, poor linkages to market, inadequate market information and dissemination as well as other socio-economic and institutional factors (Senyolo *et al.*, 2018). For instance, farming experience, farm gate price, and the quantity produced were the factors found to influence the quantity of mangoes, banana, and avocado supplied among small-scale farmers (Tadesse *et al.*, 2011; Pamphile *et al.*, 2018). Besides, household heads education level, market price, extension services, training, and middlemen affects the quantity of fruits and vegetables supplied to the market (Wollo and Mba, 2015; Jaji *et al.*, 2018; Jemal *et al.*, 2019). In Kenya, marketing of mango fruits is not well organized. It is estimated that the price of mango is low at the farm-level while postharvest losses could be of up to 30% which is a disincentive to production (Muthini, 2015).

Machakos County is the second leading producer of mangoes in Kenya after Makueni with 803,533 trees and an output of 67,320 metric tons (MT), which is valued at Kenyan shillings (KES) 835,580,274 (MoALF, 2018). Moreover, 40-60% of the population in the county engage in the mango value chain. Several studies carried out in the County have focused on assessment of mango farmers choice of marketing channels and also the impact of market participation on mango famers (Mwagangi, 2012; Muthini, 2015). There is limited understanding though, about the factors that influence the quantity of mango supply. This paper, therefore, focuses on bridging the said knowledge dearth in Machakos

County, Kenya. Our contribution to the gap is two fold. First we evaluate and expand the scope of socio-economic and institutional factors that influence the supply of mangoes. Secondly we apply the Two-stage least square (2SLS) regression model that has not been widely used in similar studies for analysis.

2. Materials and methods

2.1 Description of the study area

The study was carried out in Machakos County, Kenya. The County is located on latitude 0°45′S and longitude 36°45′E. It is bounded in the West, North, East, South, South West and North West by Nairobi and Kiambu, Embu, Kitui, Makueni, Kajiado, Muranga, and Kirinyaga respectively. The County covers an area of 6,208km^2 and has a population of 1,421,932 (Kenya Bureau of Statistics, 2019). In addition, the study area receives a bimodal rainfall pattern, with the long rains experienced in March to May, while short rains are received between October and November. The average annual rainfall ranges between 500 to 1300 mm per annum and temperatures range between 18°C -25.7°C (Government of Kenya, 2018). These conditions are suitable for mango farming.

2.2 Sampling methods and procedures

The study employed two-stage stratified sampling to collect data from 352 mango farming households in Machakos County (Table 1). Firstly, the six major mango producing wards in the County (Mbiuni, Makutano/Mwala, Masii, Muthetheni, Wamunyu, and Kibauni) were purposively selected. Secondly, a location was randomly selected from each of the six wards. Further, a sub-location was selected from each location and finally, a village was randomly selected from each Sub-location. To obtain the number of mango farming households to be interviwed in each village probability proportionate to size technique was applied. In this case, the total population of mango farming households in each village was divided by the total number of mango farming households in the selected villages then multiplied by the sample size. The interval between the households to be interviewed was estimated by dividing the total number of households in the village by the required number of households as shown below.

$$M = \frac{n}{N} * 352 \qquad \ldots 1$$

Where M is the number of mango-farming households to be interviewed, n is the number of mango-farming households in the village, and N is the total number of mango-farming households in the six villages randomly selected. The second step involved identifying the first household randomly and the interval between the households. This was estimated by

dividing the total number of mango-farming households in the village by the required number of households from the village ($\frac{n}{M}$).

Table 1: Summary of mango farming households interviewed in each selected village

Wards	Location	Sub-location	Village	No.of farmers	Sample size
Kibauni	Ikalasaa	Kamuthwa	Kyeni	47	39
Makutano	Makutano/Mwala	Mathunthini	Misuuni	70	59
Mbiuni	Mbiuni	Kabaa	Kabaa	53	44
Masii	Masii	Mbaani	Kawaa	109	91
Muthetheni	Miu	Kikulumi	Makulumu	78	65
Wamunyu	Wamunyu	Kaitha	Kaitha	65	54
Total	**6**	**6**	**6**	**422**	**352**

3. Theoritical framework

This study also appealed to market supply theory to explain the relationship between the selected factors and the quantity of mango supplied to the market. Supply is the willingness and the ability to sell a good and service. This theory assumes that the supply of goods depends on the market price as well as the cost of producing goods using an additional unit (Richard *et al.*, 2011). The greater the difference between the two values the greater the willingness of producers to supply the good. The willingness to supply the goods depends on the price of that good and the wage rate. In this case, the majority of small-scale mango farmers targeted valuable markets that offer higher prices, this is determined by the quantity of mangoes produced. That is, the oversupply of mango produce to the market reflected in low prices and vice versa. This concept was represented in an individual's seller supply function equation as shown below;

$Q_X^S = f\ (p_x, w \ldots\ldots n) \ldots\ldots\ldots\ldots 2$

Where Q_X^S is the quantity supplied of mangoes, p_x is the price per unit of mangoes produced and w is labour and n represents factors such as the quantity of mangoes produced, household head age, market prices, market access, extension contact and amount of credit which had a significant influence on the quantity of mangoes supplied.

To determine the influence of the selected socio-economic and institutional factors on the quantity of mango supplied to the markets, a supply function represented in form of a stochastic two-stage least square (2SLS) multiple regression model was used to estimate the effect of selected factors on the quantity of mangoes supplied to the market. In the first stage of the 2SLS model, mango output was regressed over all the selected independent variables including the instrumental variables. The first stage equation is given as;

$$Y_{1i} = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 \ldots \ldots \alpha_n X_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where, Y_{1i} is the predicted quantity of mangoes produced by household i. α_0 is the intercept, $\alpha_1$to α_n represents the parameter estimates of the independent variables included in the equation and ε is the error term.

In the second stage of the 2SLS model, the quantity of mangoes supplied was regressed over independent variables which includes the endogeneous variable (predicted quantity of mangoes produced) and the exogeneous variables (variables used in first stage model excluding the instrumental variables). The second stage of the 2SLS equation is given below;

$$Y_i = \beta_0 + \delta_{Y_{1i}} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \ldots \beta_n X_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where Y_i is the dependent variable (quantity supplied to market), β_0 is the vertical intercept showing values of Y when variables X_1 to X_n are considered to be the factors affecting quantities of mangoes supplied. δY_{1i} is the endogeneous variable (predicted quantity of mangoes produced), $\beta_1, \beta_2 \ldots \beta_n$ are the coefficients of independent variables, while $X_1, X_2 \ldots X_n$ are the indepedent variables and ε is the error term.

4. Methods of data analysis

The study employed both descriptive and inferential statistics. Descriptive analysis consist of means and standard deviations. Further, two-stage regression model was used to analyze the determinants of the quantity of mangoes supply. The data was analyzed using STATA version 13 software. Multicollinearity, heteroscedasticity and endogeneity tests were done after model estimation. Multicollinearity problem occurs due to a linear relationship among the independent variables and therefore the separate effect of the independent variables on the dependent variables becomes difficult to identify because of the strong relationship between them (Gujarati, 2003). Multicollinearity exists when the Variance Inflation Factor (VIF) of an independent variable exceeds 10 or less than one, none of the independent

variables had VIF values less than 1 or greater than 10, implying that there was no multicollinearity problem (Appendix 1).

Heteroscedasticity test was done to ensure the regression model assumption that the residual should have a constant variance was not violated. The heteroscedasticity problem occurs when the variance of error term is not constant and affects the elasticity of output of linear regression models since the parameter estimates of such a model are likely not to be the best linear unbiased estimator. The Breusch-Pagan test was employed to check for the presence of heteroscedasticity. The chi2 (1) value was 0.11 and the probability value was 0.7367. Since the probability was greater than chi2 (1) in the Breusch-Pagan test the null hypothesis (Constant variance) was accepted and no heteroscedasticity problem in the data set (Appendix 2). The Durbin and Wu-Hausman tests were employed to check for the endogeneity problem. The results show Durbin (score) chi2 (1) = 0.3939 with (p-value = 0.03) and Wu-Hausman F (1,331) =0.3707 with (p-value =0.02). Since all the p-values were significant at $p \leq 0.05$, the null hypothesis of exogeneity of predicted quantity of mango produced was rejected at 5% level of significance (Appendix 2). This indicated the presence of endogeneity problem.Therefore, two stage least square model was used to address the endogeneity problem.

Two Stage Least Square (2SLS) model uses two separate stages during analysis in order to avoid endogeneity problems (Woodridge, 2010). Endogeneity exists when the explanatory variable correlates with the structural error term of the data set in the model. In such a situation, the disturbance term is not random hence inconsistent estimation implying that, the coefficient estimates of the independent variable fail to converge to the true value of the coefficient as sample size increases. Endogeneity problem occurs due to omission of variables, measurement error in variables, and simultaneous causality (Woodridge, 2010). In order to obtain consistent estimation, application of instrumental variables (IV) estimation is recommeded because to cut correlation between the error term and independent variables. The instrumental variables should meet two requirements; uncorrelated with the error term and strongly correlated with endogeneous regressor (quantity produced). In this case land size, pesticides and manure were used as the instrumental variables. The validity of the instrumental variables was tested at this stage. The F-statistics results was found to be 77.38%. The rule of thumb indicate that F less than 10 indicates invalid instrumental variables. For this case, F-value was greater than the critical value hence this indicated valid instrumental variables.

5. Results and discussion

5.1 Descriptive statistics

The results shows that, majority (73%) of the respondents were male farmers (Table 2). This implies that mango farming in the study area is dominated by male farmers. Besides, the mean age of the respondents was 57.82 years. This indicates that elderly people dominate in mango farming. Furthermore, the mean of household size was 6.0. On average, the sampled household years of schooling (education) was 10 years. Education enables farmers to make well-versed decisions and detect market opportunities where they exist. The mean number of years spent in mango farming (farming experience) was 16.66years. This indicates that most of the farmers had a good experience in mango farming. The average farm size was found to be 1.29 hectares. This shows that farmers have adequate land for mango production. The mean household income among the mango farmers in the study area was (KES 25599.43). Moreover, the average number of extension contact was found to be 2.0. This implies that small-scale farmers in the study area had access to information regarding mango production and marketing.The mean of the predicted amount of mango produced by the farmers in the study area was 3011.20 kilograms.

Table 2: Farm and farmers characteristics of the sampled farmers

Variables	Mean	Std. Dev
Gender (1=male, 0=female)	0.73	0.02
Age (years)	57.82	11.65
Household size	6.0	1.65
Education (years)	10.00	2.29
Farming experience(yrs)	16.66	9.09
Total farm size (hectares)	1.29	0.55
Household income (KES)	25599.43	25547.15
Extension contact (visits)	2.0	1.20
Quantity produced (kgs)	3011.20	1833.50

Source: Authors (2020)

5.2 First stage regression results for 2SLS model

The results of the first stage for 2SLS model are presented in Table 3. In this stage the quantity of mangoes produced was analysed over the independent variables including the instrumental variables. The results shows that land size, manure and pesticide had the

strongest correlation with predicted quantity of mango produced hence qualified to be used as the instrumental variables in the study. Land size had a positive and significant effect on quantity of mangoes produced at 1% level of significance. The results indicate that an increase in land size by one unit increased the quantity produced by 0.5011 units. In addition, manure had a positive and significant effect on quantity of mangoes produced at 1% level of significance. The results also indicated that an increase in the amount of manure by one unit increases the quantity produced by 0.5747 units. Pestcides had a positive and significant effect on the quantity of mangoes produced at 5% level of significance. The results show that an increase in pesticide application to mango trees by one unit increases the quantity produced by 0.6047 units.

Table 3:Factors affecting quantity of mangoes produced

Variables	Coef.	Standard error	t	P-value
Gender (1=male, 0=female)	-0.0474	0.0524	-0.90	0.366
Household head Education (level)	0.0324	0.0651	0.50	0.618
Distance to nearest market (Km)	-0.0234	0.0569	-0.41	0.680
Distance to motorable road (Km)	-0.0654	0.0716	-0.91	0.362
Household age (yrs)	0.1211	0.0579	2.09	0.034
Household size	0.1300	0.1108	1.17	0.242
Land size (hectares)	0.5011	0.0460	10.90	0.000***
Farming experience(years)	0.2675	0.0818	3.27	0.001
Market prices (KES)	-0.2252	0.1388	-1.62	0.106
Family labour (Man-days)	-0.1797	0.0841	-2.14	0.033
Hired labour (Man-days)	0.0175	0.0358	0.49	0.626
Manure (kgs)	0.5747	0.2038	2.82	0.005***
Market information	-0.1616	0.1940	-0.83	0.406
Market access	0.1040	0.0555	1.87	0.062
Training (1=Yes, 0=No)	0.0463	0.0366	1.27	0.206
Off-farm income (KES)	0.2002	0.0781	2.56	0.011
Group membership	0.3599	0.0757	4.75	0.000
Pesticides (Kgs)	0.6047	0.2838	2.13	0.037**

Source: Authors (2020); (***P≤ 0.01, **P≤ 0.05)

5.3 Determinants of market supply of mangoes among small-scale farmers

The second stage of 2SLS regression model presented the determinats of the quantity of mangoes supplied (Table 4). The dependent variable (quantity supplied to the market) was determined as the amount of mangoes sold from the yield after considering household consumption, the amount purchased for sale and amount given or received as gifts but was sold during harvesting season. The independent variables are hypothesized to explain the change in the quantity supplied. Based on the results, the coefficient of determination R^2 was 0.9225 indicating that a combination of independent variables used in the regression model explained 92.25% of the variation in the dependent variable with the remaining 7.75% been due to uncontrollable factors in the regression model.

The regression coefficient of quantity of mangoes produced was positive and significant at 1% level of significance. The results indicate an increase in amount of mangoes produced by one unit resulted to an increase in market supply of mangoes by 0.8944 units. The credible explanation of this is that farmers who produce more output are expected to supply more to the market than those who produce less. The higher the farmer produces, the more likely the household would supply. These results agree with Tadesse, (2011) and Ayalew, (2015) that the quantity produced positively influenced the amount of market supply of fruits.

Age of household head had a negative and statistically significant influence on quantity supply of mangoes. The relationship shows that an increase in the age of the farmer by one year reduces the quantity of mangoes supplied to the market by 0.1455 units. This may be explained by the fact that majority of the youths in the study area have increased the quantity of mango marketed through use of available modern technology platforms such as Mkulima Young online. These results are consistent with the findings of (Geoffrey *et al.*, 2014; Megerssa *et al.*, 2020) that young people participate much and supply more produce to the market compared to the older people because they are more receptive to new ideas and are less risk averse than older people.

Market price had a positive and significant influence on the quantity supplied at 1% level of significance. The results indicate that, an increase in market price by one unit resulted to an increases in the quantity supplied by 0.1741 units. This positive relationship reveals that the probability of quantity of mangoes supplied is higher when the market price of mangoes is high. The results further point out that higher market prices would enhance the farmer willingness to produce more and in effect increase the quantity of mangoes sold to the market by small-scale farmers. These results are in line with Birachi *et al.* (2011) and Jaji *et al.* (2018) findings that an increase in price had a positive influence on the quantity of beans and pineapples supplied to the market respectively.

In this study, market access was considered as the availability of local markets that are adjacent to the mango farmers and where they meet with the buyers to sell their produce. Market access showed a positive and significant influence on market supply of mangoes by 0.0571 units. Majority of small-scale mango farmers in the study area sell their produce to local markets and particularly during market days. This is explained by the fact that, these markets are the meeting points of various buyers and mango sellers where there is free haggling which determines prices rather than selling to the brokers at the farm gate. These results corroborate with Sebatta *et al.* (2014) and Osmani and Hossain, (2015) that farmers who have access to market usually produce and supply more to the market than their counterparts without such opportunities.

The coefficient of extension contact was positive and significant at 5% level of significance. This implies that an increase in contact between the extension officers and farmers increases the quantity supplied by 0.1919 units. Extension contact improves the ability of mango farming household to acquire new technologies and capacities of production, further improve productivity and in turn increases the market supply. Similarly, extension contact was found to influence the quantity of produce supplied to the market among small-scale farmers (Siziba *et al.*, 2011; Tedesse *et al.*, 2011; Abrha *et al.*, 2020). Contrary, Tegegn, (2013) and Wosene *et al.* (2018) found that the frequency of extension service had a negative effect on the quantity supplied to the market as farmers who access extension service do not appropriately apply the techniques and advice suggested by the extension agents.

Amount of credit accessed with respect to marketing was positive and significant at 1% level of significance. The results show that an increase in the amount of credit accessed by one unit increases mango market supply by 0.1925units. Farmers who have access to credit would increase their financial capacity as it assists to make proper decision regarding purchasing of mango farming inputs e.g seedlings, manure, pesticides and labour that increases mango production and quantity of market supply. These results are in line with studies by (Bongiwe and Micah, 2013; Tesfaw, 2014; Mahlet, 2015; Girmalem *et al.*, 2019) that access to credit influenced the quantity of cabbage, pepper, potato and mangoes supplied to the market respectively.

Table 4: Determinants of the quantity of mango supplied to the market (2SLS results)

Variables	Coef.	Robust S.E	Z	P-value
Quantity of mangoes produced (Kgs)	0.8944	0.03918	22.8300	0.0000***
Gender (1=male, 0=female)	-0.0125	0.0241	-0.5200	0.6020
Household head education level	0.0242	0.0299	0.8100	0.4190
Distance to nearest market (Km)	0.0056	0.0262	0.2100	0.8300
Distance to motorable road (Km)	-0.0317	0.0330	-0.9600	0.3380
Household head age (Yrs)	-0.1455	0.0512	-2.8400	0.0040***
Household size	-0.2476	0.1325	-1.8700	0.0620
Farming experience(Yrs)	0.0325	0.0390	0.8300	0.4050
Market prices (KES)	0.1741	0.0644	2.7000	0.0070***
Family labour (Man-days)	0.0323	0.0393	-0.8200	0.4100
Hired labour (Man-days)	-0.0179	0.0164	-1.0800	0.2780
Market information	0.0943	0.0894	1.0600	0.2910
Market access	0.0571	0.0258	2.2100	0.0270**
Training (1= Yes, 0=No)	0.0161	0.0169	0.9600	0.3390
Off-farm income (KES)	0.0340	0.0368	0.9300	0.3550
Group membership	0.0272	0.0375	0.7300	0.4680
Farm size (hectares)	0.0310	0.0288	1.0700	0.2830
Extension contact (No.of visits)	0.1919	0.0962	1.9900	0.0460**
Amount of credit (KES)	0.1925	0.0270	7.1200	0.0000***

Source: Authors (2020); (***P≤ 0.01, **P≤ 0.05); Prob > chi2 = 0.0000, R^2 = 0.9225

6. Conclusions and Recommendations

In Kenya, tropical fruits such as mangoes play a great role in the household economy. Machakos County has good potential for mango production but with less market-oriented activities. Despite the economic importance of mango fruit in the study area, there has been limited studies relating to marketing. Mangoes have a relatively high value in the domestic markets. However, a lot of the mango produce has often been used for domestic consumption with little reaching the market due to multiple factors. This study established that the quantity of mangoes produced, market prices, market access, extension contact and

amount of credit accessed positively influenced the quantity of mangoes supply, while the age of the household head precipitated a negative effect. The study recommends to the farmers to increase the quantity of mangoes produced by applying modern methods of farming and management practices which in turn reflects increased supply to the market. In addition, there is need to increase extension contact between mango farmers and extension agents so as to update farmers knowledge and skills with improved production and marketing system. It is also crucial to support mango farmers with adequate financial support through greater access to affordable credit for production and marketing purpose.

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Appedix 1

Test for Multicollinearity problem for the explanatory variables

Variable	VIF	1/VIF
Household age (yrs)	6.97	0.143
Farming experience(years)	5.12	0.195
Training (1=Yes, 0=No)	4.94	0.202
Market information	4.01	0.249
Extension contact (No.of visits)	3.85	0.260
Group membership	3.27	0.306
Distance to nearest market (Km)	2.50	0.400
Education (level)	2.38	0.420
Family labour (man-days)	2.34	0.427
Market prices (KES)	2.30	0.436
Household size	2.25	0.444
Distance to motorable road (Km)	2.14	0.467
Off-farm income (KES)	1.63	0.612
Market access	1.58	0.633
Farm size (hectares)	1.37	0.728
Amount of credit (KES)	1.35	0.741
Gender (1=male, 0=female)	1.10	0.912
Hired labour (Man days)	1.09	0.917
	Mean VIF= 2.79	

Appendix 2

Test for Heteroscedasticity and endogeneity

Heteroscedasticity test

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

Ho: Constant variance

Variables: fitted values of quantity sold

chi2(1) = 0.11

Prob > chi2 = 0.7367

Endogeneity test

Durbin (score) chi2(1)= 0.3939 (p = 0.03)

Wu-Hausman F(1,331)= 0.3707 (p= 0.02)