FARM-LEVEL SUPPLY AND VALUE ADDITION OF MANGOES AMONG SMALL-SCALE PRODUCERS IN MACHAKOS COUNTY

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DECLARATION

This thesis is my original work and has not been presented elsewhere for a degree or any other award.

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DEDICATION

I sincerely dedicate this work to the Almighty God for the gift of life, strength, and guidance during my studies. I also dedicate this work to my loving family, to my grandmother Nzavi John, brother Erastus and my sisters Carol and Rachael.

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LIST OF ABBREVIATIONS

ASAL	Arid and Semi-Arid Lands
CRS	Constant Return to Scale
DRS	Decreasing Return to Scale
IRS	Increasing Return to Scale
FAOSTAT	Food and Agriculture Organization Statistics
GDP	Gross Domestic Product
HCD	Horticultural Crops Directorate
KES	Kenyan Shillings
KNBS	Kenya National Bureau of Statistics
LM	Lower Midland
MOA	Ministry of Agriculture
MOALF	Ministry of Agriculture, Livestock, and Fisheries.
MT	Metric Tonnes
OLS	Ordinary Least Square
RUM	Random Utility Theory
SDG	Sustainable Development Goals
STATA	Statistics and Data
SPSS	Statistical Package for Social Sciences
RU	Random Utility
TPP	Total Physical Product
VIF	Variance Inflation Factor

DEFINITION OF TERMS

Farm-level value addition- Any action that takes a (raw) product a step closer to the form in which it can conveniently meet the need (s) of the user (s). This study considered farm-level value addition as all aspects of value addition done by the farmers at the farm level that takes mango fruits to a form closer to meeting the needs of the user such as making natural juices, dessert, slice and package, sorting and grading, packaging, and cold storage.

Quantity supplied - The quantity of a commodity that the producer is willing and able to sell at a particular price and time. In this study, quantity supplied was determined as the number of mangoes sold from the yield after considering household consumption, the amount purchased for resale, and the amount given or received as gifts but sold during harvesting season.

Market- A market was considered as the physical and virtual arrangement between the mango buyers and sellers to exchange goods and services for money.

Big Four Agenda- This is a document that identifies and defines the four priority initiatives (food security and nutrition, manufacturing, affordable health care and affordable housing) to be implemented by the Government of Kenya for five years (2017-2022). This study contributes to food security and nutrition which is one of the "Big four" agenda for the Government of Kenya.

ABSTRACT

Mango *(Mangifera indicia L.)* is one of the most suitable fruit crops in arid and semi-arid areas of Kenya. Its production in Machakos County has generally been fluctuating over the past few years, such that there is no consensus whether the production is increasing or decreasing. In addition, there is a paucity of knowledge about the quantity of mangoes supplied by small-scale farmers. Upon harvest, the mango fruit is highly perishable, therefore farmers have taken up farm-level value addition strategies to enhance the shelf life so as to improve market access. In this respect, this study sought to establish what influences farm-level supply and value addition of mangoes among the producers. The specific objectives addressed herein were; to determine the effect of selected factors on mango production, to assess the factors influencing the quantity of mangoes supplied to the market, and to evaluate the effect of selected factors on farm-level value addition. The study was conducted in six mango growing Wards of Mwala Sub-County in Machakos County. Data were collected by administering a semi-structured interview schedule to 352 small-scale mango producers, who were identified through two-stage stratified sampling and probability proportionate to size technique. Results of the Cobb-Douglas production function showed that both family and hired labour, pesticides, and manure were the main inputs that influenced mango production. Furthermore, household size, mango farming income, farm size, amount of credit, and extension contact had a positive effect on mango production, while the costs of pesticides and manure had a negative effect. Further, the two-stage least square regression model revealed that the quantity of mangoes produced, market prices, market access, extension contact, and amount of credit positively influenced the quantity supplied. On the contrary, the household head age exhibited a negative influence on the quantity supplied. Finally, the Heckman two-stage selection model results revealed that off-farm income, access to cold storage facilities, price of value-added products, group membership, extension contact, farmers' awareness, amount of credit, and hired labour had a positive significant influence on the probability of farmers' participation in farm-level value addition. This study recommends firstly that; the small-scale mango farmers should allocate more land to mango farming so as to increase the level of output. Secondly, farmers should adopt high-yielding mango varieties such as apple variety and apply good management practices to increase the quantity produced, which in turn will reflect in increased market supply. Thirdly, relevant authorities in the County may consider providing adequate and up to date mango storage facilities and increase extension contacts to facilitate the uptake of mango farm-level value addition among small-scale farmers.

CHAPTER ONE
INTRODUCTION

1.1Background information

Mango *(Mangifera indicia L.)* is one of the most important fruits in the tropics and subtropics. It is commercially grown in more than 90 countries worldwide and consumed in both fresh and processed forms (Mathooko *et al*., 2013; Mujuka *et al*., 2020). Additionally, mango 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; Bundi *et al*., 2020). The world production of mango is estimated to be about 21.5% metric tons per year and continues to increase yearly at a rate of 2.6% (Okoth *et al*., 2014). In particular, Asia is the biggest producer of mangoes with 76.9% of the total production, followed by America 13.38%, Africa 9%, Europe and Oceanic countries 1% (Jahurul *et al*., 2015). Globally, mango production in rural areas is gaining significance as a response to increased demand derived from its ability to produce natural juices and blended to other products such as Pickles, chutneys, jam, and jelly and also offering jobs in its entire value chain and its contribution to the rural economies (Korir *et al*., 2013; Chappalwar *et al*., 2020). Despite the relevance of developing mango farming activities among small-scale farmers in Africa and integrating in them, farmers have inadequate information on the importance of the enterprise and this contributes to declining farm income (Singh and Priyadarshi, 2016; Oduol *et al*., 2017).

Kenya is among the leading mango producers in Africa (Galán, 2010). Moreover, mango is the second most important fruit in terms of area and production after banana (Food and Agriculture Organization Statistics (FAOSTAT, 2015). Statistics show that mango cultivation contributes approximately 5% of the Agricultural Gross Domestic Product (GDP) in Kenya and about 2% of the national GDP, employing a considerable number of the seasonal labour force (Ministry of Agriculture, Livestock and Fisheries, 2018). In 2015, the area under mango production was 46,364 hectares (ha) and the output was 806,575 metric tonnes (MT), while in 2016 the area under cultivation increased to 49,098 ha but the output reduced to 779,147 MT (Horticultural Crop Directorate, 2016). Eastern Kenya

leads in mango production with over 42,000 hectares (Muthini, 2015). In February and March of every year, even when there is a near-total crop failure, substantial mangoes are still harvested which creates a major source of income for both farmers and casual labourers (Mwangangi *et al*., 2012). However, mango production is faced with many challenges such as; seasonal variation in production over the years, post-harvest losses, and limited access to information on value addition (Mulinge, 2015). Furthermore, large quantities are lost during the peak period as a result of poor post-harvest handling and poor marketing strategies as the farmers lack enough information on the choice of the marketing channels, hence the amount that is supplied to the market from the farm remains undefined (Muthini, 2015).

Supply of the agricultural produce to the market comprises of activities such as planning for the production, grading, transport, distribution, and pricing, sending information from the farm to the market, and from the market to the farm (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 (Gashaw *et al*., 2010; Jemal *et al*., 2019). Marketing of the agricultural produce enables small-scale farmers to increase their household income hence able 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 many problems more so for the perishable horticultural produce like mango fruits. This makes small-scale farmers opt for value addition to enhance shelf-life as well as market access hence boosts their income (Agwu *et al*., 2015; Ntale *et al*., 2015; Donkor *et al*., 2018; Salvioni *et al*., 2020).

Value addition is the process of converting a product from its original form to a more valuable form through the creation of value and innovation (Oyewole and Eforuoku, 2019). This enables small-scale farmers to reduce post-harvest losses for perishable fruits and thereby offering them opportunities to maximize returns (Tobin *et al*., 2016). In this study, mango value addition involved deliberate activities at the farm-level that transform mango fruits and make it more valuable. Some of the value-added products made from mango fruits at the farm-level include; mango juices, dessert, sliced and packed, dried mango,

among others. Moreover, value addition also signifies changing a raw product into something new through storage, packaging, processing, and drying or any other type of process that differentiates the product from its primary form. However, the agrarian economy of Kenya is suffering from limited value addition as statistics show that only 6% of small-scale farmers add value to their farm produce (Ntale *et al*., 2015). In addition, small-scale farmer's interest to add value to their products is largely limited to the market environment, supportive services, processing technologies, infrastructure, institutional, economic, and socio-demographic factors (Gashaw *et al*., 2018).

Approximately 60% of the population in Machakos County engage in the mango value chain. The area under mango production is 5,593 ha with a production of 67,320 MT valued at approximately KES 835,580,274 per harvesting season (MoALF, 2018). Despite this, there has been seasonal fluctuations in the amount of mango output obtained by the farmers in the area due to inadequate knowledge on various agronomic management practices (MoALF, 2018). Several studies carried out in the County have focused on the assessment of mango farmers' choice of marketing channels and the impact of market participation on farmer's income (Mwagangi, 2012; Muthini, 2015). There is limited understanding though, about the quantity of mangoes supplied to the market and various factors that influence production and the market supply. Furthermore, previous studies have looked at the various mango value addition strategies adopted by the farmers (Mbithe, 2012; Kennedy, 2015). However, factors influencing mango farm-level value addition and its extent documented, thus the need for the study. Therefore, this study primarily purposed to assess the selected factors affecting farm-level supply and value addition of mangoes among small-scale producers in Machakos County.

1.2 Statement of the problem

Mango is one of the most suitable crops for arid and semi-arid areas in Kenya. Recently, its production in Machakos County has been fluctuating over the last few years. There have been seasonal variations in the amount of output obtained by the farmers. During the peak seasons though, it is common that farmers experience huge post-harvest losses since the production of mangoes exceeds the consumption requirement at the farm-level. As a result,

farmers look for accessible markets to sell off their glut produce. Often farmers are excluded from markets due to long value chains, low prices, and the presence of numerous players. Intermediaries involved in the marketing process buy mangoes at relatively low prices depriving the farmers of the willingness to supply mangoes to valuable markets. In functional markets, farmers would expect to sell most of their produce as suppliers in the market. In spite of the foregoing, factors that influence mango production and supply remain unclear. Furthermore, farmers are carrying out mango farm-level value addition so as to address the problem of high perishability, enhance the shelf life as well as expand the market access. Yet still, there is scanty information on the determinants of mango value addition as well as the extent of farm-level value addition among small-scale producers. This study, therefore, comes in handy to fill in the identified gaps.

1.3 Objectives

1.3.1 General objective

To assess the factors affecting farm-level supply and value addition of mangoes among small-scale producers in Machakos County

1.3.2 Specific objectives

1. To determine the effect of selected factors on mango production among small-scale mango producers in Machakos County
2. To assess the factors influencing the quantity of mangoes supplied to the market among small-scale mango producers in Machakos County
3. To evaluate the effect of selected factors on farm-level value addition among small-scale mango producers in Machakos County

1.4 Research questions

1. What are the effects of selected factors on mango production among small-scale mango producers in Machakos County?
2. What factors influence the quantity of mangoes supplied to the market among small-scale mango producers in Machakos County?

3. What is the effect of selected factors on farm-level value addition among small-scale mango producers in Machakos County?

1.5 Justification of the study

Mango is more versatile than all other fresh fruits and this makes it suitable to thrive in arid and semi-arid lands (ASALs) of Kenya. However, the potential benefit of the crop is under-utilized due to its high perishability resulting in high post-harvest losses during peak seasons. Activities such as an increase of mango output, market supply, and farm-level value addition can boost farmers' income, hence enhancing their livelihood in rural areas, which contributes to the attainment of the Sustainable Development Goal (SDG) number one, which is to alleviate poverty at all levels by 2030. Improving mango enterprise goes along in promoting the overall growth of the horticultural industry in Kenya. This may play a pivotal role in the attainment of vision 2030 economic pillar that aims at increasing annual economic growth by 10%. Moreover, improved income promotes access to food among rural farmers, and this attribute to food security and nutrition, which is one of the "Big Four Agenda" of the Kenyan government. Therefore, this study sought to provide research-based information to the producers, extension officers, and policymakers on how to improve farmers' income and food security through improved production, market supply and farm-level value addition among small-scale mango producers.

1.6 Assumptions of the study

The study assumed that farmers would provide the necessary information required. The study was also based on the assumption that small-scale farmers in the study were involved in mango production, market supply, and farm-level value addition. Validation of the assumptions was obtained by carrying out a content validity test since the farmers had the relevant information. Finally, appropriate adjustments were done in order to enable the collection of the information.

CHAPTER TWO
LITERATURE REVIEW

2.1 An overview of the mango sub-sector in Kenya

Mango is the second-ranked most important fruit after banana in Kenya contributing about 21% foreign income of total exported fruits (Horticultural Crop Directorate, 2016). Mangoes are produced by both large and small-scale farmers for either export or domestic consumption. Over 98% of the produced mangoes are domestically consumed at the farm-level (Mujuka *et al*., 2020). About 5% of the produced mangoes are sold to processing industries (United States Agency for International Development, 2018). Mango is grown in different parts of the Country where the Eastern region leads in mango production followed by the Coastal region with 3 million and 1.4 million mango trees. Mango production generates about 2.4 billion per annum at the farm gate contributing 22% of farm household income in the Eastern region. Machakos County has 803,533 mango trees that generate about KES 835,580,274. Over 70% of mango trees grown in the County, apple variety is highly preferred as it takes a short time to mature and has high market demand. Other exotic mango varieties include Kent, Tommy, and Vandyke (Sennhenn *et al*., 2014; MoALF, 2018).

2.2 Factors affecting production among small-scale mango producers

Studies conducted in Sub-Saharan Africa (SSA) have revealed various factors influencing agricultural production. The level of education, household head age, farming experience, farm size, and household income had a significant positive effect on agricultural production among small-scale farmers (Anigbogu *et al.*, 2015; Dessale, 2019; Kumar *et al*., 2020). However, information on the effect of extension contact and credit access on farm output was limited in these studies.

Mango production among small-scale farmers in Ethiopia was found to be constrained by limited mango varieties, extension services, pest and disease prevalence, scarcity of irrigation water, and limited technologies (Hussen & Yimer, 2013). This study omitted other factors such as education level, land, labour, and farmer experience. Results by Juma

et al. (2019) indicated that avocado varieties, access to inputs, pest and diseases, drought, limited extension service, and market access affected the level of avocado output among small-scale farmers, other factors such as farm size, active family and hired labour, access to credit and cost of pesticides were not included. Additionally, education level, farming experience, farm size, labour, extension services, and access to inputs had a positive and significant effect on apple production. However, active family and hired labour, farm size, credit access, cost of pesticide, and manure were left out in the analysis (Ntakayo *et al.*, 2013; Osmani and Kambo, 2019).

Other factors found to influence the level of agricultural output include farm size, physical capital, inputs, prices, extension services, and education (Mallya, 2014; Julien *et al*., 2019; Tasila *et al*., 2019; Zulu *et al.*, 2019). These studies omitted other key variables such as farming income and credit access, which may adversely affect agricultural farm output. Therefore, given the reviewed literature, it is clear that studies have identified various farm and farmers' characteristics that affect the level of agricultural output. However, factors such as active family labour, farming income, cost of inputs, and household size have hardly been addressed. Hence, this study aimed to fill this gap in the existing knowledge.

2.3 Factors influencing the quantity supplied to the market

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 the purchase of necessities (Martey *et al*., 2012). In Kenya, brokers form the largest group of mango sellers. They operate primarily 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, the quantity of produce supplied to the market as well as market participation decrease due to low prices and other factors that deprive farmers' willingness to participate in market supply (Shiferaw *et al*, 2011; Panda and Sreekumar 2012). Previous studies have established numerous factors

affecting the market supply of various agricultural produce. For instance, Tura *et al.* (2016) double hurdle model results revealed that household size, proximity to market, farm size, and price, off-farm activities, and livestock holding influenced the proportion sold to the market among small-scale farmers. The study did not expound on other factors such as quantity produced and credit access.

The Ordinary least square regression model results by Mengesha *et al*. (2019) indicated that gender, farm size, market distance, farming experience, extension service, and family labour affected the market supply of mangoes. The study did not include other factors such as the number of mangoes produced and market prices. Tadesse *et al*. (2011) and Pamphile *et al*. (2018) found that farming experience, farm gate price, and the quantity produced influenced the quantity of mangoes, banana, and avocado supplied. However, there was scanty of information on the influence of market access, extension contact, and credit access on market supply.

Several studies reported that household heads education level, market price, extension services, training, and middlemen affect the quantity of fruits and vegetables supplied to the market, other variables such as quantity produced, household head, household size, market access, and market information were omitted (Wollo and Mba, 2015; Jaji *et al*., 2018; Jemal *et al*., 2019). Furthermore, the proportion of produce supplied to the market among small-scale farmers was found to be influenced by group membership, farm size, village market, and non-farm income (Sebatta *et al*., 2014; Wegi *et al*., 2017). Market prices, extension contact, and access to credit were not incorporated.

A general observation from this review is that although farmers are involved in the market supply of their produce, there is inadquate information on the determinants of the quantity of produce supplied to the market. Therefore, this study sought to evaluate and expand the scope of socio-economic and institutional factors that influence the supply of mango and apply the two-stage least square (2SLS) regression model that has not been widely used in similar studies.

2.4 Factors affecting farm-level value addition

Value addition to the perishable agricultural produce is worthwhile because of the higher returns that come with the investment and opportunities to open new markets as well as extending farmers marketing seasons with the ability to create new recognition of the farms (Alonso *et al*., 2013; Coulibaly *et al*., 2014; Schiassi *et al*., 2018). Value-added fruits and vegetable products have dominated the local markets as the entrepreneurial farms take advantage of high-demand products (Allegra *et al*., 2019; Sijtsema *et al*., 2012; Ntale and Litodo, 2013). Among the fresh tropical fruits, mango occupies the second-largest portion after banana in terms of demand in the world market, and it's of more value to the farmers when in a value-added form (Altendorf, 2017; Sulistyawati *et al*., 2019; Chappalwar *et al*., 2020). However, small-scale farmers have limited information concerning value addition (Ntale and Litodo, 2013; Altendorf, 2017; Mujuka *et al*., 2020).

In the few extant studies, a limited set of factors influencing value addition in the agricultural sector have been analyzed. For instance, awareness, extension services, group membership, credit access, and market access influenced the participation of farmers in mango value addition (Mbithe *et al*., 2012; Kennedy, 2015; Bundi *et al*., 2020). However, these studies did not capture the aspect of the factors influencing the proportion of mangoes valued-added. In addition, Kennedy, (2015) found that majority of small-scale mango farmers were aware of sorting and grading as the main value addition strategy.

The Probit regression model results by Agwu *et al*. (2015) and Gashaw *et al*. (2018) indicated that household size, gender, farming experience, active family labour, extension services, access to credit, and off-farm income had a significant effect on the probability of farmers' participation in farm-level value addition. These studies did not incorporate other variables such as livestock ownership, group membership, and storage facilities. Results by Mkandawire *et al*. (2018) showed that the location of the farm, farmers' participation, type of farming, number of enterprises, and gender significantly influenced the decision of farmers to engage in value addition practices. Other key variables such as training, access to storage facilities, and livestock equivalent were not included.

Several studies done on value addition of various agricultural produce have focused on the adoption of various value addition strategies though, there is limited information on the factors affecting value addition and the proportion of produce value-added. Therefore, this study focused on the determinants of mango farm-level value addition as well as the value-added proportion by small-scale farmers to fill the identified gaps.

2.5 Research gap

Previous studies on the factors affecting agricultural farm output among small-scale farmers emphasized much on the socio-economic factors such as land, labour, farming experience, education, age, farm size, and income among others (Ntakayo *et al*., 2013; Mallya, 2014; Anigbogu *et al*., 2015; Dessale, 2019; Juma *et al*., 2019; Kumar *et al*., 2020). However, there is inadequate information on extension contact, credit access, and cost of inputs. Multiple studies have focused on the determinants of market supply of agricultural produce (Tadesse, 2011; Wollo & Mba, 2015; Jaji *et al*., 2018; Jemal *et al*., 2019) with limited information on the determinants of quantity supplied of perishable produce such as mango fruits. Furthermore, numerous studies highlighted that gender, farmers' awareness, labour, credit access, extension services, and group membership influenced farm-level value addition. Nevertheless, there is a paucity of information on other key variables such as storage facilities and livestock equivalent (Mbithe *et al*., 2012; Agwu *et al*., 2015; Kennedy, 2015; Gashaw *et al*., 2018; Mkandawire *et al*., 2018; Bundi *et al*., 2020). Besides, there is inadequate information on factors influencing the proportion of value-added produce at the farm-level. Therefore, this study aimed to fill these gaps by evaluating the selected factors influencing production, quantity supplied to the market, and farm-level value addition among small-scale mango producers in Machakos County.

2.6 Theoretical and conceptual framework

2.6.1 Production theory

Production theory is the study of production or the economic process of converting inputs into outputs. This theory was applied to explain the quantitative relationship between selected factors of production and the level of mango output. A production function is

purely the technical relationship between the physical inputs and output. It describes the laws of proportion, represents the technology of the firm, and includes all the technically efficient methods of production. According to Jhingan, (2007), a production function expresses a functional relationship between quantities of inputs and outputs. It shows how and to what extent output changes with variation in inputs during a specified period. The current study follows Snyder *et al*. (2012) specification of the general production (equation 2.1).

$Y = f(x_1, x_2, x_3 \ldots x_n)$……..….2.1

Where Y represents mango output, x_1 is land, x_2 is labour x_3 is the amount of capital used in production and x_n represents other factors that influence the farm output. The production function shows the maximum amount of mango produced using alternative combinations of land, labour, and capital. Output Y is also the total physical product (TPP) (Debertin, 2012). The marginal physical product (MPP) of an input is the additional output produced by employing one more unit of that input while holding all other inputs constant (Snyder *et al*., 2012). The Cobb-Douglas production function was applied in this study to express this production relationship. Finally, the concept of returns to scale was applied to explain the output response to simultaneous changes in all inputs used in production.

2.6.2 Supply theory

This study also appealed to 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;

$Q_X^S = f\ (p_x, w \ldots \ldots . . n)$…….2.2

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, market access, extension contact, amount of credit, and household size which had a significant influence on the quantity supplied.

2.6.3 Random utility theory

To explain how consumers make choices from among competing alternatives, this work applied Random utility theory (RU). This theory postulates that a consumer will make a rational choice in order to maximize utility subject to a set of constraints (McFadden, 2001). This model assumes that the decision-maker has a full discriminatory capability to choose an alternative with the highest utility. Therefore, if the costs associated with using a particular alternative are greater than the benefits, the household will be discouraged from using the alternative and shift to another option that maximizes their utility. The RU in this study was specified as shown below;

$P_{ci} = EXPv_t/\Sigma_{j\Sigma c}EXP(v_j)$ ……..…….……..2.3

Where P_{ci} is the probability of an individual farmer choosing alternative value addition technology, c is the available farm-level value addition strategies, v is the utility which summarized the desirability of the alternative value addition strategies which interact with characteristics of individual mango farmers and their choices. This formed a function which was additively separable linear equation;

$V_i = x_{i1}\beta_{i1} + x_{i2}\beta_{i2} \ldots\ldots\ldots\ldots + x_k\,\beta_k$ …….. ……..2.4

Where x_1 are the measured attributes and characteristics of the mango farmers, β_i are the important weight parameters to be estimated. Therefore, based on the concept of random utility theory, farmers were assumed to add value to their mangoes at the farm level with the expectations of deriving maximum utility which was largely constrained by the household budget (Mafuru *et al.*, 2007). In addition, small-scale mango farmers were expected to add value only when they perceived the net benefits from value addition to be greater than in the case without. Therefore, this study drew from the RU theory to explain how farmers maximize utility by maximizing profit through value addition at the farm level.

2.7 Conceptual framework

Figure 2.1 depicts how this study was conceptualized. It shows the relationship between the dependent and independent variables. The framework shows that socio-economic and institutional factors influence the uptake of value addition and farm-level supply of mangoes. Additionally, factors such as age, education level, farm size, prices, extension services, and access to credit among others affect mango production, quantity supplied to the market, and farm-level value addition. With increased production beyond the level consumed at the farm-level, the quantity supplied to the market increases. Alternatively, farm-level value addition can be opted for to reduce post-harvest losses and increase shelf-life because mango fruits are perishable. Value-added mango fruits tend to fetch higher market prices. This translates to better income hence the farmers can be food secure as food security entails access as well as affordability. Higher-income also implies better living standards translating to poverty alleviation.

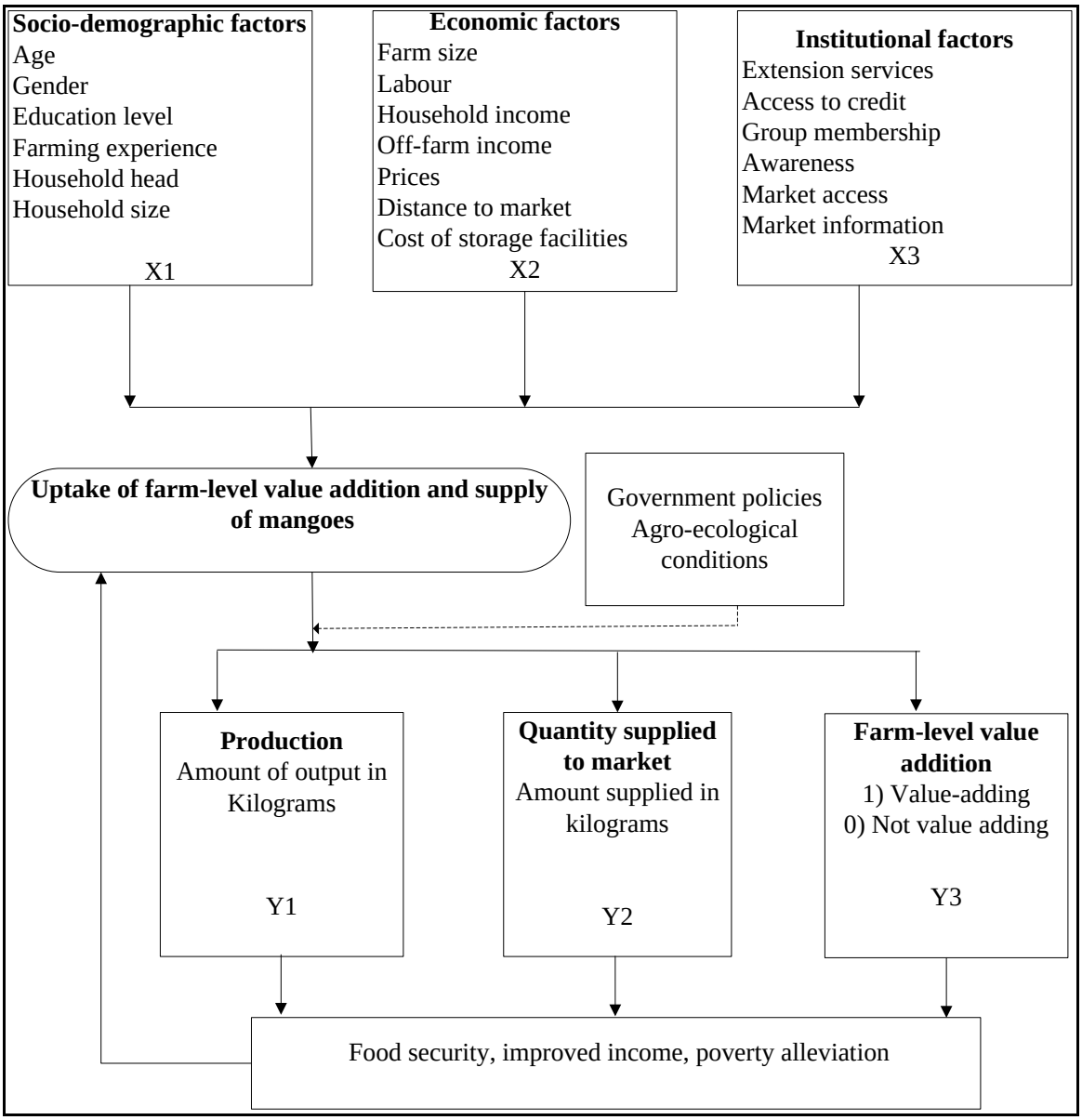

Figure 2.1: Conceptual framework

Key: Y = Dependent variables

X= Independent variables

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Study area

The study was conducted in Mwala Sub-County of Machakos County (Appendix 1). The study focused on Mwala Sub-County because of its high potential for high-value mango fruits production, marketing, and value addition. The Sub-County is located at latitude 0°45′S and longitude 36°45′E. The total population in this area is around 181,896 (Kenya Bureau of Statistics, 2019). It is classified in the lower midland zone (LM3, LM4, and LM5). The annual rainfall ranges between 500 to 1300 mm that is received in two seasons per year. Specifically, long rains are experienced from March to May, while short rains are received in October and November. Temperatures range between 18 °C- 25.7 °C with July being the coldest month, whereas December and March are the hottest (Government of Kenya, 2018). The landscape is hilly with an altitude of 1000 to 1600 meters above sea level. The soils are mainly alfisols and vertisols (Jaetzold *et al*., 2010). The main food crops grown in the County includes; maize, beans, cowpeas, pigeon peas, and cassava. The main cash crop grown in the area includes; mango, sorghum, and French beans (Ndege, 2015). Mangoes are produced throughout the County with Mwala Sub-County being the leading producer MoALF, (2018) hence was suitable study site for this research.

3.2 Research design

This research applied a cross-sectional survey design. This design was most suitable because it enabled the researcher to describe, analyze, and interpret conditions that exist in variables under study without manipulating the environment of the study. It is also cheap in terms of data collection using an interview schedule (Kothari, 2004).

3.3 Target population and sample size

The target population for this study was mango growing households in six wards of Mwala Sub-County which included Mbiuni, Makutano, Masii, Muthetheni, Wamunyu, and Kibauni. The total number of mango-growing households in these areas is approximately 17,676. To obtain the sample size of the study, the formula suggested by

(Watson, 2001) was used. This formula was applied in this work since the target population (N) was above 10,000 mango-growing households.

$$n = \left(\frac{p(1-p)}{\frac{e^2}{z^2} + \frac{P(1-P)}{N}} \right) \div R \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1$$

Where n is sample size, N-is 17,676, P is the estimated proportion (0.3), e is the desired precision (0.05), z is the confidence level (95% = 1.96) and R is the response rate 90% (0.9). The sample size was then;

$$n = \left[0.3(1-0.3) \div \left(\frac{0.05^2}{1.96^2}\right) + \left(\frac{0.21}{17{,}676}\right)\right] \div 0.9[0.21 \div 0.000] \div 0.9000 = 352$$

mango-growing households.

The sampling unit for this particular study were mango-growing households within the study area.

3.4 Sampling design and procedure

This study used a two-stage stratified sampling technique. A location was randomly sampled from each ward. From each location selected a sub-location was randomly sampled. Then, a village was randomly sampled from each sub-location. The probability proportionate to size method was used to obtain the number of households growing mango to be interviewed from the six villages. First, the number of mango-farming households from each village were determined. Proportion to size formula was applied where the number of mango-farming households in the selected village was divided by the total number of mango-farming households in all six villages and then multiplied by the sample size as shown below;

$$M = \frac{n}{N} * 352 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.2$$

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 ($\frac{n}{M}$). Data collection was carried out subject to approval by the National Commission for Science, Technology & Innovation (NACOSTI) license number 514332 (Appendix 4).

Table 3.1: Summary of 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**

3.5 Data collection instruments

Interview schedules were used to collect primary data from mango-farming households. Before data collection, enumerators were trained on the subject of study to enhance understanding of the kind of information required. The interview schedule consisted of socio-demographic characteristics of the farmers such as household head age, household head gender, household head education level, farming experience, and household head size. It also consisted of farm and farmer's characteristics such as farm size, farm income, land tenure. Information about the production, market supply, and farm-level value addition of mangoes was included.

3.6. Reliability and validity of instruments

A pre-test was done with 10 questionnaires being administered to randomly sampled farmers to ascertain their reliability (Appendix 5). On the other hand, the split-halve method was used to test the reliability of the interview schedule. The correlation coefficient (r) between halves of the items was calculated using Pearson Product linear correlation coefficient formula (Heale *et al*., 2015) as follows;

$r = N\sum Y - [\sum(X)(\sum Y)]/\sqrt{[N\sum X^2 - (\sum X^2)][N\sum Y^2 - (\sum Y^2)]}$……...3.3.

Where: X = odd scores, Y = even scores, $\sum(X)$ = sum of X scores, $\sum(Y) =$ sum of Y scores, $\sum(X^2)$ = sum of squared X scores, $\sum Y^2$ = sum of squared Y scores, $\sum XY$ = sum of the product of paired X and Y scores, N = number of paired scores, and r = coefficient correlation between halves. Since r represents one-half of the instrument, Spearman-Brown Prophesy was used to determine the reliability of the full instrument.

$Re = \frac{2r}{1+r}$ = 2 × reliability for $^1/_2$ tests / 1 + reliability for $^1/_2$ tests; r lies between 0 and 1; reliability is stronger when r value approaches one. A sample of 10 interview schedules for the pre-test helped in assessing the accuracy of the data collection instrument. Items found ambiguous and inadequate were correctly worded and re-modified to avoid misinterpretation by the respondents. The instruments yielded a correlation coefficient, r of 0.763 for the full instrument. Since reliability is assumed to be stronger for r values approaching 1, the reliability coefficient of 0.763 implies that the data collection instrument was adequately reliable.

3.7 Analytical tests

Before data analysis was initiated, heteroscedasticity and multicollinearity tests were done to test whether there was any correlation within the explanatory variables (independent variables) for both log linearized Cobb-Douglas production model and two-stage least square (2SLS) multiple regression model.

3.7.1 Multicollinearity test

A multicollinearity test was done to check whether the independent variables were linearly correlated prior to analysis using the Cobb-Douglas production function model and two-stage least square (2SLS) multiple regression model. The existence or non-existence of multicollinearity is explained based on the values of the Variance Inflation Factor (VIF). The VIF value of the predictor variables should neither be greater than 10 nor less than one (Gujarati, 2003). In particular, a VIF value greater than 10 indicates multicollinearity (Allison, 2001). Consequently, it can therefore be concluded that multicollinearity exists if the VIF values exceed 10 or smaller than 1. The results

presented in chapter four showed no multicollinearity since none of the variables had VIF less than 1 or greater than 10.

3.7.2 Heteroscedasticity and endogeneity test

Heteroscedasticity is a problem that arises when the variance of the error term is not constant. In this study, a heteroscedasticity test was done to ensure the regression model assumes that the residual should have a constant variance that was not violated. Heteroscedasticity affects the outputs 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 chi-square value was 0.11 and the probability value was 0.7367. Since the probability was greater than chi-square in the Breusch-Pagan test the null hypothesis (Constant variance) was accepted and no heteroscedasticity problem was found in the data set (Appendix 2).

Endogeneity exists when the explanatory variable correlates with the structural error term in the model during the data generating process. In such a situation, the error term is not random and the estimation is inconsistent, which implies that the coefficient estimates of the independent variable fail to converge to the true value of the coefficient in the population as sample size increases. Recent literature emphasizes three primary instances where the condition of exogeneity becomes violated and therefore endogeneity occurs. This includes the omission of variables, measurement error in variables, and simultaneous causality (Woodridge, 2010). Therefore, to address the endogeneity problem, a two-stage least square model is recommended. In this study, Durbin and Wu-Hausman test was used to check for the endogeneity problem. The results show that 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 the p-value was significant at $p \leq 0.05$, the null hypothesis for exogeneity was rejected at a 5% level of significance, this indicates the presence of an endogeneity problem (Appendix 2). Therefore, 2SLS was applied to address the endogeneity problem.

3.8 Data analysis methods

Descriptive and inferential statistics were employed to analyze the data. Descriptive statistics included mean, frequencies, percentages, and standard deviations, while

inferential statistics involved the use of the empirical models to compare the results of the sampled data with the previous studies. Data were analyzed using statistical package for social sciences (SPSS version 23) and STATA version 13.

3.8.1 Determination of the effect of selected factors on mango production

To determine the effect of selected socio-economic and institutional factors on mango production, the log-linearized Cobb-Douglas production function was applied. This production function was the most suitable for this study because it provides parameters that are easy to estimate and interpret. The general Cobb-Douglas production function is of the following form (Tadesse and Krishnamoorthy, 1997):

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 \ldots + \beta_n \ln X_n + \alpha_1 z_1 + \cdots \alpha_1 z_n + \varepsilon \ldots\ldots\ldots\ldots\ldots 3.4$$

Where Y is the mango output, β_0 is the vertical intercept, and $X_1\ to\ X_n$ are quantities of inputs used. $\beta_1\ to\ \beta_n$ are the inputs co-efficient of the regressor or multiplier that describes the size of the effect the inputs have on the dependent variable Y. α_1 is the coefficient for socio-economic and institutional factors and $z_1\ to\ z_n$ are the socio-economic and institutional factors. ln is natural logarithm and ε is the composite error term.

3.8.2 Assessment of factors influencing 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, the predicted quantity of mango produced was regressed over all the independent variables including the instrumental variables. The equation is given as;

$$Y_{1i} = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 \ldots\ldots \alpha_n X_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

Where, Y_{1i} is the predicted quantity of mangoes produced by household i. α_0 is the intercept, α_1 to α_n represents the parameter estimates of the independent variables included in the equation and ε is the disturbance term.

In the second stage of the 2SLS model, the quantity of mangoes supplied was regressed

over independent variables, which included the endogenous (predicted quantity of mangoes produced) and exogenous (variables used in first stage model excluding the instrumental variables) variables as described in the next chapter. The second stage of the 2SLS equation is given below;

$$Y_i = \beta_0 + \delta_{Y_{1i}} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \ldots \beta_n X_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots 3.6$$

Where Y_i is the dependent variable (quantity supplied to market), β_0 is the vertical intercept, $X_1 \; to \; X_n$ are considered to be the factors affecting quantities of mangoes supplied. δY_{1i} is the endogenous 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 independent variables and ε is the error term.

3.8.3 Evaluation of selected factors on farm-level value addition

Heckman, (1979) two-stage selection model was used to evaluate the effects of the selected socio-economic and institutional factors on the extent of farm-level value addition. This model combines the probit model and truncated regression model to determine factors affecting farm-level value addition and the extent of value addition. The probit model was used to determine the farm-level value addition of mangoes (1=value-adders, 0=non-value adders) as stated below;

$$pr\left(Z_i = \frac{1}{w_i \alpha}\right) = \emptyset[h(w_i, \alpha)] + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.7$$

Where Z_i is the farm-level value addition of mangoes, $\emptyset$ is standard normal cumulative distribution function, h, w_i, α are the socio-economic and institutional factors affecting farm-level value addition, ε_i is an error term. The outcome of equation 3.7 gives a general linear regression model of the first stage as shown below;

$$p_{i(0,1)} = \beta_0 + \beta_1 X_1 + \beta_1 X_2 + \ldots + \beta_n X_n + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.8$$

Where $p_{i(1)}$, represents farmers adding value to mango, while $p_{i(0)}$ represents farmers not adding value to mangoes**,** β_0, $\beta_1 \; to \; \beta_n$ are parameters to be estimated using the model. X_1 to X_n are selected socio-economic and institutional factors affecting farm-level value addition. The second stage equation according to Heckman, (1979) is specified as follows;

$$E\left(\frac{Y_i}{Z} = 1\right) = f\left(X_{i,} \beta\right) + \lambda \frac{\emptyset[h(w_i, \alpha)]}{\emptyset\,(w_i, \alpha)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.9$$

E is the expected operator, Y_i is the proportion of mangoes that are value-added, and β is a vector of the corresponding coefficient to be estimated.

The results of equation 3.9 of the second stage give a general linear regression model as specified below;

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.10$$

Y_i is the proportion of mangoes value-added by farmers β_0, β_1 to β_n are parameters to be estimated using the model, X_1 to X_n represents the selected socio-economic and institutional factors affecting the extent of farm-level value addition, ε is an error term.

4.0 Operationalizing the study variables

Table 3.2 summarizes the study variables, descriptions, measurement, and expected signs. The positive effect is denoted using (+), while the negative effect is depicted using (-).

Table 3.2: Descriptions, measurements, and expected signs of key variables

Variable	Description	Measurement	Expected sign
Production	Amount in kilograms	Amount of mango output in Kilograms	
Quantity supplied to the market	Amount in kilograms	Total amount supplied to the market.	
Farm level value addition	Level of mango value addition	Proportion of mangoes value added	
Age	Number of years	Age in years	+
Gender	Gender of respondent	1= male, 0= female	+
Household size	Family members	Number of household members	+
Education	Education level attained by the respondent	1) Primary ,2) Secondary 3) College, 4) University	+
Farm size	Farm acreage	Number of hectares	+
Farming experience	Farming experience	Number of years	+
Extension contact	Whether farmers access or do not access.	The number of visits	+
Off-farm income	Income from another enterprise part from farm enterprise income	1) Remittances, 2) pension 3) business	+
Access to credit	Household access to credit	Amount of credit accessed in Kenyan shillings	+
Group membership	Belonging to farmers group	1)Yes, 2) No	+
Household income	Households monthly income	Income in Kenyan shillings	+
Market information	Access to market information	1) access, 2) do not access information	+

CHAPTER FOUR

RESULTS

4.1 Overview of the chapter

This chapter presents the descriptive statistics of selected farm and farmers characteristics of the mango farmers in the six wards of Mwala Sub-County, Machakos County. It also presents the results of the models concerning the factors influencing production, quantity supplied to the market, and farm-level value addition as well as its extent among small-scale mango farmers, the chapter presents an interpretation of the results.

4.2 Selected farm and farmers' characteristics of the sampled farmers

The selected farm and farmer's characteristics were classified into socio-economic and institutional characteristics. The socio-economic characteristics are those factors related to the resources and the characteristics of the household head. The socio-economic factors related to the characteristics of the household head include age, gender, marital status, household head education level, household size, and farming experience. On the other hand, the socio-economic factors related to household resources include household income, both off-farm and farm income, and assets owned by the farmers such as land, livestock, cold storage facilities, blenders, crates, and boxes used by farmers for value addition.

The institutional factors consist of services that are provided by both public and private institutions that support agricultural production and agro-based cottage industries in Machakos County. Such services include farm-credit, extension services, agricultural training institutions, farmer's cooperatives, government policies, road infrastructure as well as technological support from research institutions. These services are rendered to the farmers by the County government of Machakos and non-governmental organizations operating in the study area. The descriptive statistics of the farm and farmer characteristics are given in Table 4.1.

The descriptive statistics demonstrated that the majority (73%) of the respondents were male farmers. This implies that the male farmers in the study area dominate mango

farming. In addition, the mean age of the respondents was 57.82 years indicating that elderly people involved more in mango farming activity compared to the youths who engage in other off-farm activities. An average household had six members. On average, the sampled household head years of schooling (education) was 10 years. Education empowers a farmer to make informed decisions on production, marketing, and identify value addition opportunities where they exist.

The mean number of years spent in mango farming (farming experience) was 16.66 years. This indicates that most of the farmers have engaged in the farming of mangoes for many years and thus they had a good experience in mango farming. The mean of the total land size occupied by the respondents was 2.5 hectares. Concerning farm size, the average farm size under mango farming was 1.29 hectares, which implies room for expansion of the mango enterprise.

The mean household income among the mango farmers was KES 25599.43 per month. Moreover, the average number of extension contacts between extension officers and mango farmers was 2.0 visits per year. This indicates that farmers in the study area received information regarding mango production, marketing, and value addition. The average amount of mango produced by the farmers in the study area was 3011.20 kilograms per harvesting season.

The results further indicate that apple variety was predominantly (80%) grown by small-scale farmers in the study area, followed by Tommy variety (56%), Kent variety (29%), and Vandyke variety with 10%. This implies that the majority of the farmers in the study area preferred the apple variety of mangoes.

Table 4.1: Farm and farmer characteristics

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 Land size (hectares)	2.5	0.67
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
Mango varieties (1=Yes, 0=No)		
Apple	0.80	0.12
Tommy	0.56	0.47
Kent	0.29	0.46
Van dyke	0.10	0.30

4.2.1 Comparison between mango value-adders and non-value adders' characteristics

In this study, farmers involved in mango value addition are denoted as value adders, while those who did not engage in value addition practices are referred to as non-value adders. The study used frequencies, means, chi-square tests, and t-tests to compare the farm and farmer characteristics of mango value adders and non-value adders as given in Table 4.2. The results indicate that 74.58% of the farmers in value addition practices are males, while 25.42% are females and the results were statistically significant at 5% level. These results show that among those involved in value addition the proportion of males was higher than that of females.

The results further indicate that 65.25% of the value adders were members of farmers group compared to 12.82% of the non-value adders. The results were significant at the 1% level, implying that the majority of farmers who practiced value addition were members of farmer groups. There was a significant difference in mean farm size (χ^2 = 0.0002) between farmers that practiced value addition (x =1.45 ha) and those that did not (x =1.22ha). This implies that farmers who practiced value addition had an average larger farm size than those who did not add value. There was a significant difference between the average number of mango trees (χ^2=0.0067) owned by farmers who

practiced value addition ($x = 22$ trees) and those who did not ($x = 19$ trees). This implies that value adders owned a higher number of mango trees compared to non-value adders.

There was a significant difference in the mean amount of credit used in value addition practices ($\chi^2 = 0.0011$) between the value adders (KES 3472.70) and non-value adders (KES 2796.20). This indicates that farmers who extensively practice value addition allocate more credit to value addition practices than those who do not. Furthermore, there was a significant difference in the mean number of extension visits ($\chi^2 = 0.0310$) between the farmers who practiced value addition (3.14 visits) and those who did not (2.54 visits). This indicates that farmers who practiced mango value addition had more contacts with extension officers than those who did not, hence prominently practiced value addition (Table 4.2).

Table 4.2: Comparison between the mango value adders and non-value adders

Variables	Value-adders (118)	Non-value adders (234)	Pooled Data (352)	
Categorical/ discrete variables				**Chi-Square test**
Gender (1= Male,0=Female)				
Male (%)	74.58	73.5	73.86	0.0467**
Female (%)	25.42	26.5	26.14	
Group membership				
Yes (%)	65.25	12.82	30.4	0.0000***
No (%)	34.75	87.18	69.6	
Continuous variables				**t-test**
Household age (yrs.)	57.64	57.92	57.82	0.8299
Farming experience (yrs.)	16.48	16.75	16.66	0.7905
Mango farming income (KES)	26165.70	24475	25599.20	0.5582
Off-year income (KES)	138330.50	118453.50	125117.30	0.3090
Farm size (Ha)	1.45	1.22	1.29	0.0002***
Prices per kg (KES)	0.25	0.24	0.25	0.4638
Livestock equivalence	41.73	40.58	40.97	0.6320
Training on value addition	3.90	3.61	3.80	0.0748
Cost of packaging (KES)	1624.70	1441	1512.50	0.2098
Number of trees owned	22	19	20	0.0067**
Household size	6.26	6.18	6.23	0.6760
Education attainment (yrs.)	9.93	7.24	10	0.0730
Amount of credit (KES)	3472.70	2796.20	3022.80	0.0011***
Extension contact (visits)	3.14	2.56	2.32	0.0310**

(***, **, show significant at 1% and 5% level of significance)

4.3 Mango farm-level value addition

The study established the frequency of farmers who practice value addition, and the value-added products and their market outlets. The subsequent sub-sections present the results and interpretation of these analyses.

4.3.1 Farmers participation in mango farm-level value addition

The results indicate that 33.52% of the 352 sampled small-scale mango farmers practiced value addition (Table 4.3). Upon value addition, mango fruit can be converted into various products of a higher value that are convenient to handle and attractive to the consumers. Of those involved in value addition, 39.77% value-added mango comprised of juice, 28.41% into desserts, 17.05% into sliced and packed mango, while 14.77% carried out all the mentioned value addition practices. This implies that majority of the farmers in the study area value-added their mangoes into juice for local consumption and sale.

Table 4.3: Farmers participation in mango farm-level value addition

Variable	Category	Frequency	Percentage (%)
Farm-level mango value addition	Yes	118	33.52
	No	234	66.48
Mango value-added products			
Mango juice	Yes	50	39.77
	No	68	60.23
Dessert	Yes	34	28.41
	No	84	71.59
Sliced and packed mangoes	Yes	20	17.05
	No	98	82.95
Mango juices, dessert, sliced & packed	Yes	17	14.77
	No	101	85.23

4.3.2 Farmers' value addition practices and their preferred markets

Table 4.4 shows the frequency of farmers in selected value addition practices. The results indicate that majority (65.25%) of the small-scale mango farmers practiced value addition in farmer groups, while 28.98% practiced value addition individually. Additionally, 5.77% practiced value addition both individually and in groups. Table 4.4 also shows results in various preferred markets by the small-scale farmers for the sale of their products. The results show that 56.82% of the respondents sold their value-added products to the local markets within the County, 34.09% sold at the farm gate, and 9.09% sold to both the local markets and at farm gate. This showed that most of the small-scale farmers preferred the nearby local open-air markets to sell their mango value-added products. A major reason for this is that open-air markets are easy to access on specific market days when the majority of local buyers turn out in large numbers.

Table 4.4: Farmers in value addition practices and their market outlets

Farmers characteristics in value addition	Frequency (118)	Percentage (%)
Categories of farmers in value addition		
Practicing value addition individually	31	28.98
Farmer groups	80	65.25
Both individually and in farmer groups	7	5.77
Markets for value-added products		
Local markets	67	56.82
Farm gate	40	34.09
Sale to local market and farm gate	11	9.09

4.3.3 Farmers awareness of mango farm-level value addition strategies

This study established several value addition strategies adopted by small-scale farmers to increase the shelf life of mangoes. The issue of whether mango farmers are aware of the selected value addition strategies such as sorting and grading, cold storage, and packaging was analyzed and results presented in Figure 4.1. Of the listed value addition strategies, 51.14% of the farmers were aware of sorting and grading, 34.09% cold storage facilities, and 14.77% packaging. This implies that farmer awareness was highest in sorting and grading and was least aware of packaging.

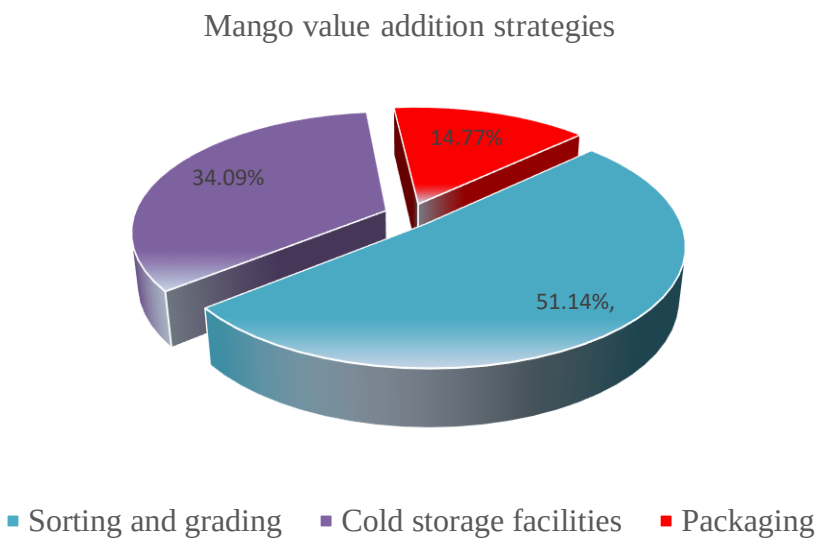

Figure 4.1: Farmers awareness of mango value addition strategies

4.4 Mango utilization in the study area

The descriptive statistics results in figure 4.2 show various preferences of mango fruits by the small-scale farmers in the study area. The results revealed that 56.82% of the respondents indicated mango farming as an income-generating activity. In addition, 22.73% of the farmers indicated that mango fruits were important for domestic consumption. About 14.20% of farmers indicated that mango fruit was useful for both income generation and domestic consumption. Further, 6.25% of the respondents used mangoes for other purposes such as a source of feed for livestock. This perhaps may be due to a lack of readily available markets to the farmers leading to large spoilage of the fruits.

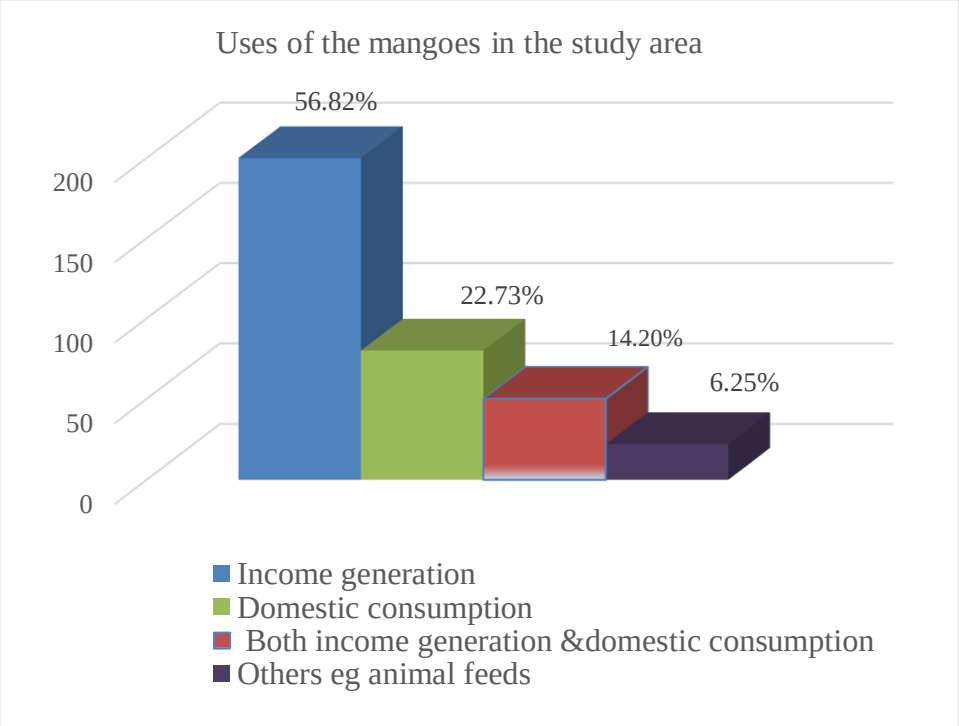

Figure 4.2: Uses of mangoes by the farmers in the study area

4.5 Selected factors affecting mango production among small-scale farmers

The study used log-linearized Cobb-Douglas production function to determine the significance of selected factors affecting mango production among small-scale farmers in the sample. The Cobb-Douglas production function was estimated using the maximum likelihood estimation procedure in STATA software version 13. The outcome of the analysis is presented in Table 4.5 and Table 4.6. The sum of the β coefficients ($\sum_{i-1}^{4}\beta_i$) indicates the return to scale of a given production function (Ndirangu *et al*., 2018). A summation of β coefficients that is less than one ($\sum_{i-1}^{4}\beta_i < 1$), indicates decreasing returns to scale (DRS), while summation equal to one ($\sum_{i-1}^{4}\beta_i = 1$) indicates constant return to scale (CRS) and that greater than one ($\sum_{i-1}^{4}\beta_i > 1$) indicates an increasing return to scale (IRS). The sum of the estimated parameters of inputs used in mango production was found to be 0.463 which is less than one (Table 4.5), implying that mango output was found to be less than the proportion at which the inputs are increased or decreasing return to scale.

The results also indicate that a value of sigma squared (σ^2) which denotes the goodness of fit and correctness of the distributional form assumed for the composite error term which had a value of 0.0600 and was significant at 1% level. The value of Log-

likelihood and that of Wald chi-square show that the specified model fits stochastic frontier estimation. Further, a lambda (λ) value of 6.4092 was significantly different from zero, thus indicating deviations between actual and predicted mango output in the study area resulted from differences in production and management practices and not random variations.

Results in Table 4.5, shows the effects of inputs on mango output. The estimated parameters in the production function expressed positive coefficients. This implies that if more inputs were applied in equitable proportions, mango production would increase by the total value of associated coefficients. With respect to labour, both the family and hired labour had significant effects on mango production. The coefficients of 0.1272 and 0.0860 respectively denote that an increase in one man-day of labour increases the amount of mango output by 0.1272 units and 0.0860 units for family and hired labour, respectively.

The amount of pesticide and manure applied had a positive effect on mango production. The coefficients of pesticides and manure were 0.1818 and 0.0684, respectively. This indicates that an increase in the amount of pesticide and manure by one unit increases the amount of mango output by 0.1818 units and 0.0684 units, respectively.

Table 4.5: The results of the effects of inputs on mango output

Variables (inputs)	Parameter	Coef.	Std. Err.	Z	P-value
Constant	β_0	6.8241	0.1331	1.2800	0.0000
Ln family labour(man-day)	β_1	0.1272	0.0650	1.9600	0.0500**
Ln hired labour(man-day)	β_2	0.0860	0.0390	2.2100	0.0270**
Ln pesticides(litres)	β_3	0.1818	0.0236	7.6900	0.0000***
Ln manure (Kgs)	β_4	0.0684	0.0118	5.7900	0.0000***
Log-likelihood		-221.3531			
Wald chi2(4)		276.1900			
Lambda		6.4092	0.0403	158.8800	0.0000
Sigma squared σ^2		0.0600			0.0000

(***, ** shows significant variables at 1% and 5%, respectively); Ln = natural logarithm**.**

Results in Table 4.6 shows the effects of selected socio-economic and institutional factors on mango production. The table gives statistical parameters that indicate various aspects of the analyzed data. These parameters include the alpha (α) coefficients, p-values (levels of significance), and the Variance Inflation Factor (VIF). The α coefficients show the effects that given changes in the independent variables would have on the dependent variable. The Variance Inflation Factor (VIF) is a test for multicollinearity between the independent variables. Multicollinearity exists when the VIF of an independent variable exceeds 10 or less than 1. In this case, none of the independent variables had a VIF value less than 1 or greater than 10, implying that there was no multicollinearity problem. The R-squared was 0.862 implying that the independent variables explained about 86% of the total variations in the mango output with the remaining 14% being due to uncontrollable factors in the model (Table 4.6).

The results reveal that household size was positive and significant at 5% level of significance. The positive α coefficient implies that an increase in the household size by one person increases mango output by 0.3875 units. The coefficient of mango farming income was positive and significant at 1% level of significance. This indicates that an increase of mango income by one unit increases mango output by 0.1851 units.

Farm size had a positive and significant influence on mango production at 1% level of significance. The results show that an increase in farm size by one hectare increases

mango output by 0.9170 units. The amount of credit used by the farmer had a positive influence on mango production at 1% level of significance. The positive α coefficient shows that an increase in the amount of credit accessed by one unit increases mango output by 0.1191units.

As anticipated, the costs of pesticides and manure had a significant negative influence on mango production at 1% level of significance. The negative α coefficients imply that an increase in the cost of pesticides and manure by one-unit reduces the amount of mango produced by 0.1818 and 0.0934 units, respectively. The extension contact positively influenced mango output at 1% level of significance. The positive α coefficient indicates that an increase in the extension contact increases mango output by 0.4726 units.

Table 4.6: Factors affecting mango production among small-scale farmers

Production (Output in kgs) Variables	**Para meter**	**Coef.**	**Std. Err**	**Z**	**P-value**	**VIF**
Gender(1=male,0=female)	α_1	-0.0748	0.0809	-0.9200	0.3550	1.09
Household age(yrs.)	α_2	0.5410	0.3386	1.6000	0.1100	4.13
Household size	α_3	0.3875	0.1807	2.1400	0.0320**	2.29
Level of education (yrs.)	α_4	0.3161	0.2329	1.3600	0.1750	3.05
Mango farming income(KES)	α_5	0.1851	0.0639	2.9000	0.0040***	1.04
Annual household income	α_6	0.0625	0.0301	2.0700	0.0780	1.53
Farm size (Ha)	α_7	0.9170	0.1664	5.5100	0.0000***	2.15
Amount of credit used (KES)	α_8	0.1191	0.0405	2.9400	0.0030***	1.24
Cost of pesticides(KES)	α_9	-0.1888	0.0607	-3.1100	0.0020***	5.95
Cost of manure(KES)	α_{10}	-0.0934	0.0333	-2.8000	0.0050***	6.07
Extension contact(visits)	α_{11}	0.4726	0.0911	5.1900	0.0000***	1.05
Constant	α_0	-5.5208	1.8275	-3.0200	0.0030	

(***, ** show significant variables at 1% and 5% levels); Prob> F = 0.0000; R-squared = 0.862; Mean VIF = 2.69

4.6 Selected factors influencing the quantity of mangoes supplied to the market

The study measured the quantity supplied to the market as a continuous dependent variable measured in kilograms. The two-stage least square (2SLS) multiple regression model in STATA version 13 software was used to determine the effect of selected factors on the quantity supplied. In the first stage of the 2SLS regression model, the

quantity of mangoes produced was regressed over all the selected independent variables to determine the instrumental variables. Instrumental variables are variables that have the strongest correlation with the quantity of mango produced. These variables were excluded from the second stage of the 2SLS multiple regression. Additionally, they were tested for validity and the results are given in Appendix 3. The F-statistic result was 77.38%. The rule of thumb indicates that F-value of less than 10 shows invalid instrumental variables (Woodridge, 2010). For this case, F-value was greater than the critical value hence this confirmed the validity of instrumental variables (Appendix 3).

The results of the first stage 2SLS multiple regression are shown in Table (4.7). The results show that land size, pesticides, and manure exhibited the strongest correlation with quantity of mango produced hence qualified to be used as the instrumental variables in this work. Land size had a positive and significant effect on the 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. Likewise, manure had a significant positive effect on the quantity of mangoes produced at 1% level of significance. The results also indicate that an increase in the amount of manure by one unit increases the quantity produced by 0.5747 units. Similarly, pesticides also had a positive significant effect on the quantity of mangoes produced at 5% level of significance. This signifies that an increase in pesticide application to mango trees by one unit increases the quantity produced by 0.6047 units.

Table 4.7: The results of the first stage of 2SLS multiple regression model

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 (litres)	0.6047	0.2838	2.13	0.037**

(***, ** show significant variables at 1% and 5% levels)

The results of the second stage of the 2SLS multiple regression model are shown in Table 4.8. Before running the regression multicollinearity, heteroscedasticity and endogeneity tests were done on the independent variables. From the results, none of the independent variables had a VIF value less than 1 or greater than 10, implying that there was no problem of multicollinearity among the variable (Table 4.8). There was also no heteroscedasticity but the endogeneity problem existed among the independent variables used as described in the previous chapter under analytical tests (Appendix 2). In the second stage, the quantity of mangoes supplied was regressed over the endogenous variable (quantity of mangoes produced) and the exogenous variables (variables in the first stage regression excluding the instrumental variables).

Table 4.8 presents the R-squared or coefficient of determination, the beta (β) coefficients, standard error, z-values, p-values, and the Variance Inflation Factor (VIF) for each explanatory variable. The R-squared shows the percentage of variation in the dependent variable that is explained by the model used. Based on the regression results (Table 4.8), 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 (the quantity of mango supplied), with the remaining 7.75% being explained by uncontrollable factors in the regression model. The β-coefficient associated with each independent variable shows the level of effect that the variable has on the dependent variable. The sign associated with the β-coefficient (positive or negative) shows the direction of the effect.

The results of the regression analysis show that the quantity of mangoes produced, household age, market prices, market access, extension contacts, and amount of credit accessed significantly influenced the quantity of mangoes supplied (Table 4.8). The regression coefficient of the quantity of mangoes produced was positively significant at 1% level of significance. This implies that an increase in the quantity of mangoes produced by one unit resulted in an increase in the market supply of mangoes by 0.8944 units.

The age of the household head had a negative and statistically significant influence on the quantity supplied at 1% level of significance. The relationship shows that an increase in the age of the household age by one year reduces the quantity supplied to the market by 0.1455 units. Furthermore, the market price showed a significant positive influence on the quantity supplied at 1% level of significance. The results indicate that an increase in market price by one unit increased the quantity supplied by 0.1741units.

Market access showed a positive and significant influence on the quantity supplied at 5% level of significance. The results indicate that increased accessibility to markets increases mango market supply by 0.0571 units. 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. Besides, the amount of credit accessed was positive and significant at 1% level of significance. This suggests that an increase in the amount of credit accessed by one unit increases the mango market supply by 0.1925 units.

Table 4.8: The results of the second stage of 2SLS multiple regression model

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 (visits)	0.1919	0.0962	1.9900	0.0460**
Amount of credit (KES)	0.1925	0.0270	7.1200	0.0000***

(***, ** show significant variables at 1% and 5% levels); Prob > chi2 = 0.0000, R-squared = 0.9225; Mean VIF = 2.77

4.7 Factors influencing mango farm-level value addition and its extent

The effects of the factors influencing farm-level value addition and its extent were determined using the Heckman two-stage regression model. The first stage of the Heckman regression model is a Probit model with a binary dependent variable (1, 0). Where 1 represents farmers practicing value addition and 0 represents farmers who are not practicing value addition. The second stage of the Heckman regression model is an ordinary least squares (OLS) model that evaluates the effects of selected factors on the extent of farm-level value addition. In this study, the extent of value addition at the farm level was measured as the proportion of mangoes produced and value-added.

4.7.1 Effects of selected factors on mango farm-level value addition

The first stage Heckman regression analysis results are presented in Table 4.9. The inverse mill ratio was significantly positive at 1% level of significance. This indicates that the error term in the Probit model results of the first stage and OLS regression model results of the second stage are positively correlated. Post-estimation of the selection equation results was done to determine the marginal effects of variables for use in interpretation. This is because the coefficients of the first regression results have no direct interpretation since they consist of values that maximize the likelihood function. The results in Table 4.9 indicate that off-farm income positively influenced the probability of farmers participating in value addition by 0.07%. Furthermore, access to cold storage facilities positively influenced the likelihood of farmer's participation in mango value addition by 3.39%.

The price of the value-added mangoes positively and significantly influence farm-level value addition among the small-scale mango farmers. The results indicate a one-unit increase in the price of value-added mango products significantly increases the probability of participation in value addition by 0.15%. Moreover, membership to a group influenced the probability of participation of farmers to value addition activities of the mango fruits by 1.93%.

Results further show that extension contact positively and significantly influences the probability of farmers engaging in value addition activities by 3.02%. Farmer's awareness of value addition influenced the likelihood of the farmer participation in farm-level value addition by 2.22%. In addition, an increase in the amount of credit used in value addition by one unit increases the probability of farmers' participation in farm-level value addition by 1.24%. Hired labour positively influenced the probability of the farmer practicing value addition. The results indicate that an increase in the number of hired labour by one man-day increases the probability of farmers' participation in value addition by 0.65%.

Table 4.9: The results of Heckman first stage Probit regression analysis

Variables	Marginal Coef.	Std. Err.	Z	P-value
Off-farm income (KES)	$0.0007e^{-4}$	$0.0009e^{-4}$	2.9200	0.0030***
Household size	0.0014	0.0095	0.5400	0.5870
Farming experience (yrs.)	0.0001	0.0019	1.8600	0.0630
Cold storage facilities	0.0339	0.0493	2.5800	0.0100**
Training on value addition	0.0071	0.0488	0.5500	0.5840
Cost of packaging (KES)	-0.0036	0.0443	0.3000	0.7610
Price of value added product	0.0015	0.0022	2.5700	0.0200**
Livestock equivalent	0.0004	0.0007	1.9000	0.0540
Distance to market (Km)	0.0056	0.0198	1.0600	0.2880
Distance to road (Km)	-0.0009	0.0301	0.1100	0.9100
Group membership	0.0193	0.0293	2.4700	0.0130**
Extension contact (visits)	0.0302	0.0275	4.1200	0.0000***
Farmers awareness	0.0222	0.0280	2.9700	0.0030***
Amount of credit (KES)	0.0124	0.0136	3.4300	0.0010***
Hired labour (Man-days)	0.0065	0.0091	2.6700	0.0080***
Cost of storage (KES)	0.0001	0.0004	1.2900	0.1970
Inverse mill Ratio		0.0329	4.5900	0.0000

(***, **, show significance at 1% and 5% levels)

4.7.2 Effects of selected factors on the extent of mango farm level value addition

The second stage Heckman regression analysis was used to determine the effect of selected factors on the extent of farm-level value addition among mango farmers. The results of the second stage Heckman regression are presented in Table 4.10. Distance to the nearest market had a negative influence on the proportion of mangoes value-added. The results indicate that an increase in distance to the market by one unit decreases the proportion of mangoes value added by 0.46 units. Besides, the number of training on value addition positively influenced the proportion of mangoes value-added by 1.72 units.

Farmer's awareness of value addition activities influenced the proportion of mangoes value added at the farm-level by 1.40 units. Moreover, the accessibility to cold storage facilities by the farmers positively influenced the proportion of the mangoes value added by 1.33 units. Livestock equivalents showed a negative effect on the proportion of mangoes that were value-added at the farm-level. An increase in the number of livestock reduced the proportion of mangoes value added at the farm- level by 0.03 units.

Table 4.10: The results of Heckman second stage OLS regression analysis

Variables	Coef.	Std. Err.	Z	P-value
Distance to market(Km)	-0.4567	0.1620	-2.8200	0.0050***
Distance to motorable road (Km)	-0.1018	0.2278	-0.4500	0.6550
Number of training on value addition	1.7168	0.3500	4.9100	0.0000***
Cost of packaging (KES)	0.4087	0.3842	1.0600	0.2870
Farmers awareness on value addition	1.4003	0.2951	4.7500	0.0000***
Group membership	0.1616	0.2944	0.5500	0.5830
Cold storage facilities	1.3285	0.3418	3.8900	0.0000***
Amount of credit	0.1734	0.2938	0.5900	0.5550
Livestock equivalent	-0.0278	0.0051	-5.4300	0.0000***
Cost of storage (KES)	0.0011	0.0041	0.2800	0.7800

(*** shows significant at 1% level of significance).

CHAPTER 5

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

This chapter provides discussion of the results, conclusions based on the findings, and recommendations to the stakeholders.

5.1 Discussion of the results

5.1.1 Farm and farmers' characteristics

The results in table 4.1 indicate that majority (73%) of the mango-farming households in the study area were male-headed. This was attributed to the fact that in most of the households' men were endowed with resources that enable mango production such as land, labour, and capital as compared to their female counterparts. This is in agreement with Muthini, (2015) results that male-headed households participated more in mango farming compared to female-headed households in Makueni County. This was due to socio-cultural factors that land and permanent crops in the region are owned by males.

The average age of all the respondents in the study area was 57.82 years. According to the constitution of Kenya, youth is a person above 18 years of age and below 35 years (Gok, 2010). The mean age of respondents in the study area was greater than 35 years and this confirms that elderly people dominate mango farming. There are various reasons why the majority of youths do not engage in agriculture. Information obtained from the sampled farmers indicated that inadequate requisite resources such as land and capital attributed to youths not engaging in mango farming. A similar study by Muthini, (2015) uncovered that majority of the youth did not engage in mango farming activities in Makueni County. Likewise, a report by the World Bank, (2018) indicates very low involvement of youths in agriculture.

The results further indicated that the majority (80%) of the small-scale mango farmers grow apple variety. The information obtained from farmers was that apple mango trees are tolerant to pest and diseases due to the moderate size of the apple trees which makes it possible for them to spray pesticides, prune the trees, maintain hygiene underground and reduce bruising during harvesting time hence increase the physical appearance and shelf-life of apple mango fruit. These results corroborated by Mulinge, (2015) and Okoth *et al*. (2014) that apple mango fruit resistant to pest and its size makes it easier for the farmers to perform management practices such as spraying and pruning.

The descriptive statistics results for comparison between mango value adders and non-value adders' characteristics show that male farmers participated more in mango value addition activities as compared to female (Table 4.2). The reason behind this is that majority of the households in the study area are male-headed and this hinders the participation of females in income-generating activities. These results are in line with findings by Ngore, (2010) and Gashaw *et al*. (2018) who reported that male-headed households are assumed to participate more in value addition activities than female-headed ones as more men have better access to value addition equipment, extension services, and credit than women.

The results further showed that the majority (65.25%) of value adders were members of farmers group (Table 4.2 & 4.4). The plausible explanation of this is that farmers in groups easily exchange ideas about making various products and mobilizes capital for the purchase of value addition equipment. Similarly, Adeyonu *et al*. (2016) found that farmers in organized groups exchange ideas about production, the status of the market, as well as technologies for value addition.

The mean farm size of value adders was greater than that of non-value adders. Farmers who practiced value addition allocated more land to mango production that subsequently leads to huge yields to cater for both domestic consumption and the excess for value addition. This implies that the scale of mango production has a positive influence on the decision to add value to the primary product. Ndege, (2015) found that farmers who had allocated a huge piece of land under fruit production were motivated to look for

information regarding value addition practices for both subsistence and commercial purpose.

The mean number of mango trees owned by value adders was greater than non-value adders. The majority of the farmers who practiced mango value addition in the study area owned a large number of trees. The reason behind this is that with an increased number of trees there is a likelihood of increased output and thus farmers can produce adequately for home consumption, marketing, and value addition. This further confirms the positive relationship between the scale of production and value addition. These results are in line with the findings reported by Osena, (2011) and Mulinge, (2015) that farmers who engaged in mango value addition practices were found to own a large number of trees compared to those who did not value add.

The mean of the amount of credit used in value addition was greater for value adders than non-value adders. The plausible explanation is that farmers who practiced mango value addition in the study area allocated more credit to value-added activities such as buying value addition equipment and ingredients compared to non-value adders who allocated credit to other activities like school fees, medical bills, and business. Orinda *et al*. (2017) found that farmers who engaged in value addition allocated more credit to those activities as compared to non-value adders.

The mean of extension contact was greater in value adders compared to non-value adders. Extension officers in the study area regularly targeted farmers who practiced mango value addition to educate them on making various mango value-added products. They also played a vital role in advising farmers on the marketing aspects of their products including the location of the buyers. These results agree with Sebatta *et al*. (2015) that farmers who value-added their products at the farm had greater access to extension contact than those who did not.

5.1.2 Mango farm-level value addition and utilization

Findings from this study showed that farmers in the study area value-added mangoes into juice, dessert, sliced, and packed (Table 4.3). These practices were relatively affordable to the mango farmers because they are resource-constrained. In addition, this type of value-added products has readily available markets within the locality. Majority (39.77%) of the farmers' value-added mangoes into juice. This is because a decade ago, there used to be mango solar driers in the study area where mango farmers were trained on value addition but the project ceased to exist. Few farmers who benefited during that time use the skills and knowledge gained in producing mango juice using the available value addition equipment such as blenders. Other value-added products from mango fruits include sliced and dried mangoes, mango powder, mango wine among others. However, this study did not find these practices in the study area as they require more advanced processing technologies which are of higher cost, hence not accessible to small-scale farmers at the farm-level (Ndege, 2015).

The results further showed that farmers' in the study area were aware of sorting and grading, cold storage facilities, and packaging as mango value addition strategies (figure 4.1). Farmers adopted these value addition strategies to ensure that, mangoes reach the market or the consumer in the right form, the one at harvesting or value-added time. These results collaborated with those of Kennedy, (2015) and Mkandawire *et al*. (2018) that storage, packaging, sorting, and grading activities were the most used forms of value addition practices by the farmers' groups.

5.1.3 Factors affecting mango production

In terms of inputs used in mango production, the results revealed that active family labour and hired labour had a significant influence on the amount of mango produced. This can be explained by the fact that mango production is a labour-intensive activity and requires extensive management practices such as pruning, spraying as well as harvesting, and this requires available and active labour. These findings are consistent with Dessale, (2018) that active family labour and hired labour were the key inputs that significantly influenced the amount of farm output obtained by the farmers. In addition, labour was found to

positively influence agricultural output among small-scale farmers (Chowdhury, 2016; Kloss and Petrick, 2018; Ombuki, 2018).

The amount of pesticide and manure applied had a positive and significant influence on mango production. The results of the study show that a one-unit increase in the amount of pesticide and manure increases the amount of output by 0.1818 and 0.0684 units respectively. Mango farmers in the study area apply farmyard manure to improve soil fertility, which in turn leads to improved quality and production while pesticides help to control fruit-fly pest, which is destructive to mango fruits. This study agrees with the findings by Ntakayo *et al*. (2013) and Hussen and Yimer, (2013) that the amount of pesticides and organic fertilizer (manure) influences apple and mango production among small-scale farmers respectively.

Household size had a positive significant effect on mango output. The plausible explanation is that mango production is a labour-intensive activity and colossal household size provides labour to undertake mango production and management activities, which in turn increases the level of output. These results are in agreement with results by Al Shadiadeh *et al*. (2012), Mallya, (2014), and Abubakar and Sule (2019) who showed that one of the most important factors influencing the level of production of small-scale farmers is the household size. This contradicts results by Muyanga and Jayne, (2019) that large household size brings competition of resource and results to sub-division of land resulting in small-sizes allocated for crops this, in turn, reduces the amount of agricultural output.

Income from mango farming had a positive effect on mango output. The plausible explanation is that income from mango farming determines the farmer's ability to access important resources and inputs such as manure, pesticides, and payments for labour, which are the key factors in agricultural production. These findings are in line with Mallya, (2014) and Alam *et al*. (2017) that income from tomato and mango farming had a significant influence on production among small-scale farmers respectively.

Farm size showed a positive significant influence on mango production. The credible explanation is that mango farmers in the study area allocated land to mango farming considering it as an income-generating enterprise (Table 4.1). Due to this occurrence

farmers considered mango to be an important and economical crop and were interested in increasing land under mango production to create room for more improved varieties thus increasing the level of output. These results are in line with reports by Muthini, (2015) and Alam *et al*. (2017), who revealed that land allocated to mango farming (farm size) had a significant influence on the level of mango output among small-scale farmers. On the contrary, previous studies have argued that smaller farms are more efficient than larger ones resulting in an inverse relationship between farm size and production (Sial and Sheik, 2012; Desiere, 2016; Daudi and Omotayo, 2018). This is because small farms are easily manageable by the poor resource-constrained small-scale farmers. However, this does not apply to permanent fruit trees like mangoes that occupy large space thus farmers require a huge piece of land in order to increase the number of trees and thus increased yield.

The amount of credit accessed had a positive influence on mango output. A plausible explanation for this is that access to credit is critical in the financing of inputs such as manure, fertilizers, pesticides, and herbicides thus increasing the chances of high production. Similarly, access to farm credits was among the essential factors needed for agricultural production, and with it, farmers were able to secure farm inputs such as; farm equipment, fertilizer, and hired labour thus increasing the level of agricultural output among small-scale farmers (Simiyu, 2014; Mohammed *et al*., 2016; Udoka *et al*., 2016).

Extension contact had a positive and significant effect on mango output. The positive impact signifies that effective and efficient extension contact between farmers and extension officers is very crucial in agricultural production as it determines how efficient improved production practices will be delivered to the farmers within their location and how these practices shall be adopted by the targeted farmers. Similary, Mallya, (2014) found that access to extension services influenced the amount of output among smallholder farmers. Contrary to these findings Ntakayo *et al.* (2013) results indicated that the number of extension visits had no significant influence on apple production among small-scale farmers. The reason behind this was that farmers did not appropriately apply techniques delivered by extension agents such as the use of improved production technologies such as pruning and spraying, among others.

As expected the cost of pesticides showed a negative influence on mango output. An increase in the cost of pesticides by one unit reduced the amount of mango output by 0.1818 units. The study found that the cost of pesticides was higher than what farmers can afford to buy and this lead to massive destruction of the fruits by fruit-fly pests thus leading to reduced levels of production. A study by Mrema, (2017) enumerated that an increase in the cost of pesticides and herbicides reduces production among small-scale farmers. The cost of manure was found to have a negative significant influence on mango production. An increase in the cost of manure by one unit reduces the amount of mango output by a factor of 0.0934 units. Information obtained from farmers who did not keep livestock was that the cost of manure was higher and thus they cannot afford. This had a side negative effect on soil fertility leading to decreased yield. These results are in line with findings by Tun *et al*. (2020) that an increase in the cost of manure reduces the amount of agricultural output in the dry zone of Myanmar.

5.1.4 Factors influencing the market supply of mangoes

The quantity of mangoes produced had a positive and significant influence on the market supply. The credible explanation for this is that farmers who produced more of the output had to supply more fruits to the market than those who produced less. The higher the amounts a farmer produced, the more likely the household would supply to the market. These results agree with Tadesse, (2011) and Ayalew, (2015) that an increase in the production of fruits by farming households increased marketable supply.

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

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 increased the quantity supplied by 0.1741 units. This positive relationship reveals that the probability of the quantity of mangoes supplied was higher when the market price of mangoes is high. The results further point out that a higher market price would enhance the farmers' willingness to produce more and in effect increase the quantity of mangoes sold to the market by small-scale farmers. These results were in line with Birachi *et al*. (2011) and Jaji *et al*. (2018) findings that an increase in market price had a positive influence on the quantity of beans and pineapples supplied to the market, respectively. Furthermore, the results have been further supported by economic theory of supply which implies that producers produce more of the product with a very high price, thus increase the marketable surplus, while they produce less of the product with a very low price (David, 2012).

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 significant influence on the market supply of mangoes by 0.0571 units. The majority of small-scale mango farmers in the study area sold their produce to local markets, particularly during market days. This is likely because these markets are the meeting points of various buyers and mango sellers where there is free haggling that 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 with limited opportunities.

Extension contact positively and significantly influenced the quantity of mangoes supplied to the market. Extension contact improves the ability of mango farming household to acquire new technologies and capacities of production, which further improve productivity and in turn increases the market supply. Similarly, extension contact influenced the quantity of produce supplied to the market among small-scale farmers (Siziba *et al*., 2011; Tedesse *et al*., 2011; Abrha *et al*., 2020). By contrast, Tegegn, (2013) and Wosene *et al*. (2018) found that the frequency of extension service negatively affected market supply, as

farmers who access extension service do not appropriately apply the techniques and advice suggested by the extension agents.

The amount of credit accessed had a positive influence on the quantity of mango supplied. The plausible explanation of this is that farmers who have access to credit would increase their financial capacity as it assists to make proper decisions regarding the purchasing of mango farming inputs such as seedlings, manure, pesticides, and labour that increase 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 has a positive significant influence on the quantity of cabbage, pepper potato, and mangoes supplied to the market respectively.

5.1.5 Factors influencing mango farm-level value addition

The results indicate that off-farm income positively and significantly influenced the probability of farmers' participation in value addition. Access to off-farm income intensifies the monetary power of the farmers to participate more in the acquisition of equipment required in mango value addition, and meet the labour expenses incurred in value addition activities. Similarly, the amount of income from off-farm activities positively influenced farmers' decision to practice value addition among smallholder farmers (Jakpa, 2016). Contrary, off-farm income had a negative influence on the decision of smallholder farmers' participation in value addition activities (Sebatta *et al*., 2015). The reason behind this was that farmers who earned outside the farm dedicated more time there than to post-harvest activities that would add value to the produce.

Access to cold storage facilities positively influenced the likelihood of farmer's participation in mango value addition. The credible explanation for this is that cold-storage facilities influence production as well as marketing because it reduces post-harvest losses during the peak season that might occur due to spoilage that results from time taken to ferry the produce to the market. These results concur with the findings by Alkan and Kumar, (2018) that storage was one of the best strategies for mango value addition and post-harvest management practice among small-scale farmers. On the other hand, Donkor *et al*. (2018)

found that lack of storage facilities reduces the active participation of farmers to value addition along the local value chain.

The results of the present study further revealed that a one-unit increase in the price of value-added mango products significantly increased the probability of participation in value addition by 0.15%. The prices of the value-added mango products were found to be higher and more attractive to sellers compared to their raw forms. These findings were consistent with Srivastava, (2017) that the price of value-added products among minor fruits in Eastern India positively influenced farmers' participation in value addition practices. Additionally, Sebatta *et al*. (2015) found that the price of value-added potato products influences the probability of farmers' participation in farm-level value addition activities among smallholder farmers in Uganda.

Group membership positively influenced the probability of participation of farmers to value addition activities. A plausible explanation for this is that membership in groups, help farmers obtain and understand more on market information. In addition, farmers in groups, can easily receive training on value addition, exchange, and generate new notions, and learn more about the benefits of value addition. These findings agree with those of (Nadhika and Krishnankutty, 2017; Donker *et al*., 2018; Mkandawire *et al*., 2018) that group membership has a positive influence on farmers' participation in value addition activities.

Extension contact had a positive influence on the probability of farmers engaging in mango farm-level value addition. Extension contact in agriculture acts as an intermediary between researchers, governments, and farmers. The extension services provided include the provision of information regarding agricultural commodity production, marketing, innovations, agricultural commodity processing (value addition activities), as well as other opportunities available to farmers. Similarly, value addition was found to be influenced by extension services (Gashaw *et al*., 2018; Mengesha *et al*., 2019; Uddin *et al*., 2019). So, the more farmers come into contact with extension officers the more they would be decisive to value addition.

Farmer's awareness of value addition strategies had a positive influence on the likelihood of farmer participation in farm-level value addition. This can be explained by the fact that small-scale farmers in the study area participated in making various mango value-added products such as mango juice, dessert, sliced, and packed (Table 4.3). In addition, farmers were aware of key-value addition practices such as sorting and grading, proper storage, and packaging (figure 4.1). These results were in line with Bonabana *et al*. (2015) finding that awareness influenced participation in value addition technologies.

The amount of credit used in value addition influenced the probability of farmers' participation in mango farm-level value addition. A reasonable explanation for this is that access to credit is critical in financing investments and for purchasing value addition equipment as well as paying for various mango local processing operations. Likewise, an increase in the amount of credit accessed positively increased the probability of farmers' participation in value addition activities among small-scale farmers (Sarma *et al*., 2016; Mujuka *et al*., 2019).

With labour, the availability of hired labour enumerated a positive influence on the probability of the farmer practicing value addition. Labour is a key input in production, value-addition, and marketing. The local processing of mango fruits requires physical labour input to carry out various activities such as peeling, sieving, and packaging. The results were similar to those of Kuma *et al*. (2011) and Tadesse *et al*. (2017) that showed the availability of a hired labour force positively influenced value addition among smallholder farmers.

5.1.5.1 Factors influencing the extent of mango farm-level value addition

Distance to the nearest market had a negative and significant effect on the proportion of mangoes value-added. The plausible explanation is that distance to the nearest market is a proxy for the access of information sourced from the market, thus farmers whose farms are located closer to the market have more interaction with this information. Besides, this would create awareness about value-addition, provide price information, and overall market conditions. These findings agree with the results by Kuma *et al*. (2011) and Khoza

et al. (2019) that participation decisions and intensity of value addition were negatively associated with distance from the market outlet.

The number of training on value addition positively affected the proportion of mangoes value-added. The credible explanation of this is that training on value addition brings a considerable impact on the participants in terms of the extent of perceived knowledge and acquisition of the skills on value-added activities. These findings concur with those of Adeyonu *et al*. (2016) and Pandey *et al*. (2017), that training on value addition significantly increases the proportion of produce value-added at the farm-level. This contradicts findings by Bundi *et al*. (2020) that training had a negative significant effect on the extent of mango value addition among small-scale mango farmers. The probable reason behind was that majority of farmers did not turn out for the training

Farmer's awareness of value addition strategies positively affects the proportion of value-added mangoes at the farm-level. This indicates that farmer's awareness of value addition increases his/her willingness to make efforts in value-adding mangoes as well as understanding more on the upcoming value additions techniques. These results agree with Ndege, (2015) and Egbunonu *et al*. (2019) findings that increased farmer's awareness increases the proportion of the value of the fruit added through increased access and use of knowledge on fruit processing technologies among smallholder farmers.

The accessibility to cold storage facilities by the farmers positively affects the proportion of value-added mangoes. This indicates that farmers' access to storage facilities influences production and marketing since farmers can handle losses due to high yields. Cold storages increase the shelf life of perishable products. These findings are similar to those of Kyomugisha *et al*. (2018) that access to the storage facilities positively and significantly influenced the extent of the on-farm value addition of potatoes among small-scale farmers. In addition, Coolbot cold storage facilities increased the proportion of value-added on the mangoes among small-scale farmers in Embu County (Mujuka *et al*., 2020).

Livestock equivalent negatively affected the proportion of the mango value added at the farm-level. Due to lack of readily available markets for mango during the peak seasons in

the study area, farmers feed their produce to the livestock and this reduces the amount of value-added mangoes. In addition, an increase in the total number of livestock owned by the farmers may bring about the competition of the resources, and thus farmers might concentrate much on livestock rather than other farm-level value addition activities that yield better prices hence the negative effect. These findings are in line with those of (Osena, 2011; Davis and D'Odorico, 2015) that having other enterprises such as livestock keeping brings in a competition of resources with crops and thus reduces the amount of produce value-added in the value chain.

5.2 Conclusions

This study purposed to determine the effect of selected factors on mango production, market supply, and farm-level value-addition among small-scale producers in Machakos County.

In conclusion, active family and hired labour, pesticides, and manure were the inputs that influenced mango output with a 0.463 return to scale. Further, household size, mango farming income, farm size, amount of credit, and extension contacts were the factors that exhibited a positive effect on mango production among small-scale farmers, while the cost of pesticides and cost of manure showed a negative influence on mango production. The area of land allocated to mango enterprise by small-scale farmers determines the number of trees owned and this reflects the level of output. Extension contact between the farmers and extension officers is vital as it determines how efficient improved mango production practices will be delivered to the farmers within their location and how these practices shall be adopted by the targeted farmers. In addition, the size of the household determines the number of active family labour involved in mango farming since mango production is a labour-intensive activity.

The quantity of mangoes produced, market prices, market access, extension contact and amount of credit accessed positively and significantly influenced the quantity of mangoes supplied to the market. Household head age precipitated a negative effect on the market supply of mangoes. The amount of credit allocated to mango farming about marketing activities such as packaging, transportation, and payment of labour determines the quantity

of market supply. In addition, an increase in extension contact between extension officers and small-scale farmers increases their knowledge and skills on production and marketing including the location of buyers thus increasing quantity supplied. Moreover, an increase in the age of the household head decreased mango market supply since the majority of the youths in the study area preferred marketing through online platforms.

The study further established that off-farm income, access to cold storage facilities, price of value-added products, group membership, extension contact, farmers' awareness, amount of credit, and hired labour positively influenced the probability of farmers' participation in mango farm-level value addition. Further, the extent of mango value addition is positively influenced by training, farmers' awareness, access to cold storage facilities, while the distance to market and livestock equivalent precipitated negative effects on the proportion of value-added mangoes. Cold-storage facilities influence production as well as the marketing of mango fruits and its products because it caters to losses that might occur due to spoilage resulting from time taken to ferry the produce to the market. An increase in extension contact between agents and farmers enables the exchange of ideas in making various mango value-added products and learn more about value addition in a corporate manner. Training of small-scale farmers on value addition increases farmers' knowledge and skills as well as increasing farmers' willingness to practice value addition; this in turn increases the proportion of mangoes value added at the farm-level.

5.3 Recommendations

Based on the findings from this study the following recommendations are proposed to the various stakeholders.

5.3.1 Factors affecting mango production

- The study recommends to small-scale farmers to allocate more land to mango farming so as to create room for expansion of the enterprise hence this reflects an increased level of output.

- Extension contact showed a significant effect on mango output. Therefore, this study recommends to the Ministry of Agriculture in collaboration with the County Government and other private sectors to strengthen the extension contact between farmers and agricultural extension agents by making frequent visits to mango farmers and organizing training programs to encourage them to apply good management practices for improved production.

- Household size influenced the level of mango output. The size of households was a key determinant of active family labour to be involved in mango farming activities, thus the study recommends to households with large size to increase the number of active family labour involved in mango production since it is a labour-intensive activity.

- Cost of manure and pesticides reduced the amount obtained from mango farming. Therefore, the study recommends the promotion of mixed farming so as to reduce the cost associated with buying manure. In addition, the County Government should target mango farmers and provide them with pesticides to control fruit-fly pests that are destructive to mango fruits.

5.3.2 Factors influencing the market supply of mangoes

- The study recommends to farmers to increase the quantity of mangoes produced by growing mango varieties that yields more such as apple variety and apply good management practices like pruning and spraying which in turn reflects increased supply to the market.

- Farmers should allocate more credit to marketing aspects to increase the quantity supplied. Furthermore, the relevant authorities should support small-scale mango farmers to have greater access to affordable credits for marketing purposes.

- The Ministry of agriculture through the County Government and private sectors should increase the number of extension contact with mango farmers to update their knowledge and skills concerning the marketing system.

5.3.3 Factors affecting mango farm-level value addition

- Access to cold storage facilities influenced the likelihood of farmer's participation in mango value addition. The Ministry of Agriculture in collaboration with the County Government and other private sectors should increase the number of cold storage facilities in the study area to promote mango value addition and the proportion value-added.

- Extension contact influenced the probability of farmers' participation in mango farm-level value addition activities. The relevant authorities should improve the number of extension contacts and methods of extension service delivery in order to increase the uptake of mango farm-level value addition through the dissemination of information regarding value addition practices.

- Training of farmers on value addition practices increased the proportion of value-added mangoes. Since the majority of mango value adders in this work are members of organized groups, the relevant authorities should target those groups for the provision of training on mango value addition practices.

5.4 Areas for further research

This study looked at the factors affecting production, farm-level supply, and value addition of mangoes among small-scale farmers in Machakos County. However, there is an urgent need to assess the influence of the County Government on mango production, factors influencing market linkages of mangoes, and the effect of farm-level value addition on income among small-scale mango farmers.

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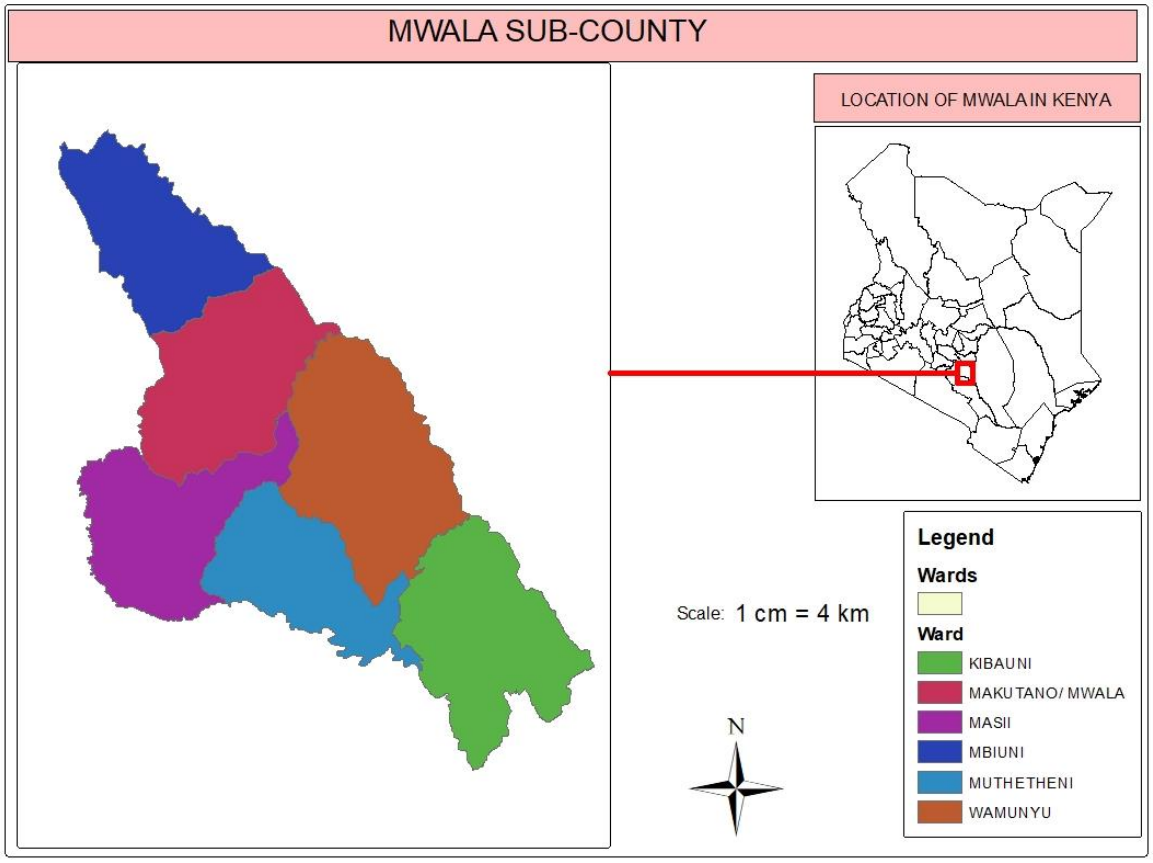
APPENDICES

Appendix 1: Map of the study area



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

Ho: variables are exogenous
Durbin (score) chi2(1)= 0.3939 (p = 0.03)
Wu-Hausman F(1,331)= 0.3707 (p= 0.02)

Appendix 3: First-stage regression summary statistics

Variable	R-squared	Adjusted R-sq.	Partial-R-sq.	F(3,330)	Prob>F
Quantity of mangoes produced	0.7546	0.7390	0.4129	77.3761	0.0000
Minimum eigenvalue statistic = 77.3761					

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Appendix 5: Questionnaire

Farm-Level Supply and Value Addition of Mangoes among Small-scale Producers in Machakos County, Kenya

Introduction

This interview schedule aims to collect data on farm-level value addition among small-scale mango producers in Mwala, Machakos County. The information provided herein will be treated with the utmost confidentiality.

INTERVIEW SCHEDULE NO: ☐

GENERAL INFORMATION

Enumerator:	Ward
Sub location	Village

SECTION A: SOCIO-ECONOMIC INFORMATION

A1 household head gender	1=male 0=female
A2 Marital status of the household head	1= married 2=window 3= widower 4= single
A3 Household head age in years	
Household family size	
A4. i) household head Education level	1=primary 2=secondary 3=college 4= university
ii) Household years spent in school	
A5. Household head occupation	1= farming 2= business 3=employment
Sources of household income	1= Mangoes 2= watermelons 3=oranges 4 Others
A6. Household farm income per year in KES	
A7. Sources of off-farm income	1= self-employment 2= salaried jobs 3= pension 4=wages 5 others specify……..
The off-farm income per year in KES	

A8.No. of years spent in mango farming	
Livestock owned	1= Cattle ……2= goat…..3= poultry.....4 others specify
Livestock value (Kes)	1……. 2…….... 3…… 4…….

SECTION B: MANGO PRODUCTION

1) Do you grow mango trees in your farm (1=YES 0= NO)

2) If YES, what is the total farm size under mango production?..... acres

3) Which varieties of mangoes do you grow (1=Apple, 2 = Tommy,3=Kent, 4 =Van dyke 5= Others (specify)……

4 What is the amount of mangoes harvested in your farm in last season……...

Variety	No of trees	Amount in bags	Harvest time	Size of the mangoes	Quality
Apple					
Kent					
Tommy					
Van dyke					

5) Do you experience any change in the output due to weather variation? (1=Yes 0= No)

6) If Yes, what is the rate of change on output caused by weather variation? (1= High rate 2= neutral 3= low rate)

7) Do you practice irrigation on your mango farming? (1=Yes, 0=No)

8) If Yes, which type of irrigation do you carry out? (1= sprinkler 2= drip irrigation 3= other specify……...)

9) How often do you practice irrigation on your mango farming? (Once a day, Twice a day, Thrice a day)

10). Identify the type of land ownership (1 = Owned with title 2 = Owned without title 3 = Rented)

11) What is the source of labour for your farm? (1 = Family labour 2 = Hired labour 3 = Both family and hired labour)

12) If family labour, how many members of your household are involved in active farm labour?.....

13) If hired, who does the work? (1= men 2= women 3= Children)

14) Please indicate the number of hours worked per day…….....

15) Please fill the number of days worked…….....

16) Please indicate wages per day men……, women……. Children…….

17) What is the cost of the inputs used in mango farming?

Input	**Amount**	**Cost per kg/litre**
Fertilizers		
Manure		
Pesticides		
Herbicides		
Others specify		

Extension services

18) Do you receive agricultural extension service or information? (1= YES 0 = NO)

19) If YES, from where do you get the extension information? (1 = County extension officers 2 = Farmer Groups 3 = Non-Governmental Organizations 4 = Television 5 = Radio 6 = Newspapers/ magazine 7 = Others (specify)……

20) How often did you receive extension support? (1 = once a year 2 = Twice a year 3 = Thrice a year 4 = Others (specify)…….

Information on access to credit

21) Do you have access to any farm credit? (1 = YES 0 = NO)

22) If YES, provide the information required in the table below;

B1	1=Banks 2= SACCO 3= Government 4= Merry go round 5=others specify……
B2	Amount of credit borrowed
B3	Amount used in mango farming
B4	Purpose for credit (1= mango farming 2= school fees 3= medical 4= others specify
B5	Constraints in obtaining the credit (1= fear of risk 2= high interest rate 3= lack of collateral 5= others specify)

C) QUANTITY SUPPLIED TO THE MARKET

23) Do you sell mangoes? Yes ( ) No ( ).

24) If Yes, how do you access mangoes to sell?

Means of access	**Quantity accessed (kgs)**	**Quantity sold (kgs)**
Own farm production		
Purchase from other mango farmers		
Gift		
Others specify		
		Total supplied=

25)Where do you sell mangoes? (1 = Local market 2 = Farmer cooperatives 3 = Institutions/schools 4 = Brokers Others (specify……

26)What is the price of mangoes per kilogram in the market during harvest season……...?

Market Access/information

27) Do you access market information on the farm produce? (1=YES 0=NO)

28) If (YES) What are your means of accessing market information (please indicate with a tick

Means	Radio	Tv	Extension services	seminars	MoA	News papers	phone	Online platforms	Others specify
Response									

Distance to market

29) What is the distance from your farm to the nearest market? …… kilometres

30) Which means of transport do you use to transport mangoes to market?.....

Road infrastructure

31) What is the distance from your farm to the nearest motorable road? …… km

32) How do you rate the road referred to in 10 above in terms of accessibility?

(1 = Highly accessible 2 = Less accessible 3 = Not accessible)

Farmer organizations

33) Are you a member of any farmer group? (1 = YES 0 = NO)

34) If YES, specify the group (1 = Kenya Farmer Association 2 = Cooperative society 3 = NGOs

4 = Women groups 5 = Others (specify)…….

35) What kind of information/ benefits do you receive from the farmer group(s) mentioned in (12)

above? (1 = Marketing 2 = Training 3 = loans 4 = Improved seedlings 5 = Others (specify)……...

D) FARM-LEVEL VALUE ADDITION

36) Do you practice farm-level value addition on your mango fruits? (1=YES 0=NO)

37) If YES, what is the main motive towards that? (1= Reduce Post-harvest losses, 2= fetch high market prices, 3= attract customers, 4= others specify……...)

38) If NO, why? .....

39) What form of farm-level value addition do you carry out to your mangoes? (1=making juices 2= storage 3=sorting and grading 4= Boiling 5=packaging (others specify) …….

40) What motivated you to choose the form of farm-level value addition strategy?.....

41) Which is the most popular form of farm-level value addition in this (local) area? ……..

42) Do you receive any kind of training on farm-level value addition? (1 = YES 0 = NO)

43) If YES, what is the source of training? (1 = County extension agents 2 = Cooperatives society 3 = Non-Governmental Organization 4 = Others (specify)…….

44) Please indicate the amount of mangoes value added through the above strategies?.....

Type of value addition	Proportion value added
Making juices	
Storage	
Sorting and grading	
Packaging	
Others specify	**Total proportion value added =**

45) Which Asset do you use to add value your mangoes?

Asset	Value	Activity

46) How did you acquire the assets? (1 = loans 2 = inheritance 3 = credit purchase 4 = lease 5 = Others specify……)

47) What more assets do you need to advance your value addition?.....

48) The following statements indicate the challenges to value addition of mangoes. Indicate by ticking the extent at which they are agreeable to you.

Statement	Strongly Agree	Agree	Disagree	Strongly disagree.
Lack of awareness on how to add value				
Government not doing much to avail training on value addition				
Farmers not been on groups to value add				
Ripe mango been cumbersome to manage				
Lack of financial facilities				
Inadequate processing facilities				

49) In which form do the locals consume mango fruit in Machakos County (please indicate by a tick

Raw mangoes	
Mango juices	
Sliced packed mango	
Dried powder	
Dessert	
Any other specify	

Thank you.