An Economic Analysis of Mango Production in Kitui County, Kenya

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ABSTRACT

Mango (Mangifera indica L.) is produced and consumed globally, with value addition offering significant economic benefits (Kundu et al, 2020). In Kitui County, post-Covid efforts demonstrated how mango processing can enhance economic performance and reduce poverty (Mutua et al, 2022). However, traditional production and marketing methods have hindered the adoption of more efficient and innovative approaches (FAO, 2019). The focus of this study was an economic analysis of mango production in Kitui County, Kenya. The main objective was to conduct an economic analysis of mango production in Kitui County, Kenya. Specific objectives included; to identify the main resources influencing the production of mango in Kitui County, to determine whether farmers efficiently utilize the identified resources and finally to determine which of the identified resources significantly influences mango production. Primary data was collected via questionnaires, while secondary data was sourced from relevant literature. Data was analyzed using SPSS version 30.0. Findings revealed that most mango farmers were smallholders on 1–20-acre farms, with 84.4% of farmers solely dependent on agriculture and livestock for their livelihoods. Popular mango varieties included Apple, Tommy, Kent (exotic), Ngowe, and Dodo (local), while Vandyke, Keit, Boribo, and Batawi were less preferred. Pest management methods varied, with 37.4% using Integrated Pest Management (IPM), 17.5% biological control, 26.1% chemical control, and 19.1% not using any method—largely due to a lack of consistent extension services for 70% of farmers. Additionally, 75% of mango growers did not engage in value addition, while 25% processed mangoes into juice and flakes through cooperatives. The study found that investments in fertilizer, labor, transport, and agricultural technology significantly increased profitability. The study recommends that research organizations such as KARLO should establish certified propagation centers to provide farmers with affordable, high-quality varieties like Kent and Keitt in order to enhance mango production. It also recommends that government financial support should be directed through cooperatives to help farmers invest in essential infrastructure such as irrigation systems and value-added processing plants; that private sector and NGOs involvement should be encouraged to supply subsidized inputs and promote sustainable farming practices; capacity building programs as well as the adoption of Integrated Pest Management (IPM) should be promoted to ensure environmentally sustainable and high-quality mango production.

Keywords: Mango Production, Value Addition

INTRODUCTION

Agriculture, forestry, and fisheries are the three industries that contributed the most to the worldwide rise in value-added creation. The global value added in agriculture increased by an average of 2.9% per year between 2013 and 2022, growing from USD 3.0 trillion to USD 3.8 trillion (FAO, 2024). With significant contributions from the Global South, the global agricultural sector saw a nearly fourfold increase in productivity between 1961 and 2020 (USDA ERS, 2024). In real terms, the combined value of agriculture, forestry, and fisheries rose by 84% between 2000 and 2021, reaching USD 3.7 trillion in 2021 (FAO, 2024). In Africa, the agricultural sector plays a key role in the economic growth of many countries. Horticulture, a vital subsector, has significantly influenced this growth due to the high-value output of products such as fruits. Mango

(Mangifera indica L.) is one of the most valuable tropical and subtropical fruits in Africa, contributing substantially to the region's economy (FAO, 2021). Over the last two decades, many Sub-Saharan African countries have experienced strong economic growth, though this progress has largely failed to reduce poverty or inequality (African Development Bank et al., 2017). With the world's largest uncultivated arable land and a sizable labor pool, Sub-Saharan Africa holds enormous potential for agricultural expansion (Kanu et al., 2014).

Agriculture remains the backbone of Kenya's economy, providing income for the vast majority of rural communities. The sector accounts for 20–31% of the country's GDP, with an additional 27% contributed through linkages to other industries such as manufacturing, distribution, and services. It employs over 40% of Kenya's workforce and more than 70% of its rural population (CBK, 2024). Despite its importance, agriculture in Kenya has struggled with profitability in recent years, primarily due to heavy reliance on rain-fed farming, limited mechanization, and inadequate infrastructure. The sector accounted for 18% of formal employment, representing more than 15.5% of total formal jobs, and contributed 65% of Kenya's total exports as of 2023 (Embassy of the Republic of Kenya in Japan, 2013). However, Kenya's agricultural GDP fell from KES 539,507 million in the second quarter of 2024 to KES 380,925 million in the third quarter, reflecting the sector's volatility (KNBS, 2024). Additionally, the economy grew by 5.0 percent in the first quarter of 2024, compared to a rise of 5.5 percent in the same quarter of 2023. The expansion was mostly supported by substantial increases in Agriculture, Forestry and Fishing (6.1%), Real Estate (6.6%), Financial and Insurance (7.0%), Information and Communication (7.8%), and Accommodation & Food Services (28.0%). Like the first quarter of 2023, agricultural output was robust in the equivalent quarter of 2024, due to good meteorological conditions that facilitated crop and livestock production throughout this period (KNBS, 2024).

Horticulture plays a crucial role in Kenya's agriculture, particularly in rural areas. Fruits, vegetables, and flowers make up a significant portion of Kenya's horticultural exports. In the first 10 months of 2023, Kenya exported 580,648 tons of horticultural goods, surpassing the 572,290 tons shipped in 2022 (CBK, 2023). Increased exports of fruits, vegetables, and cut flowers contributed to this growth. Despite this, revenue from horticultural exports fell by 3.5% in the first half of 2024 due to reduced shipments to European and Asian markets (KNBS, 2024). The total earnings during this period were KES 86.8 billion (USD 673 million), down from USD 697 million in 2023. Kenya's main horticultural markets in Europe remain the Netherlands and Britain, while China, India, and Kazakhstan lead in Asia. Collaborations with Ethiopia, Rwanda, Tanzania, and Uganda through the Common Market for Eastern and Southern Africa (COMESA) and the East Africa Community Horticultural Accelerator program aim to explore new markets (KNBS, 2024). Mango farming has become increasingly popular in Kenya, particularly in the southeast region, where mangoes are quickly overtaking bananas as the dominant fruit crop due to favorable climatic conditions. Mangoes are well-suited to Kenya's agro-ecological zones, thriving in temperatures between 10°C and 42°C with rainfall levels between 500–1000 mm, making them ideal for arid and semi-arid lands (ASALs), (Affognon, et al., 2015; Kitinoja and AlHassan, 2012).

Kenya remains one of the world's top mango producers, with an annual output exceeding 800,000 metric tones. The foreign market for Kenyan mangoes accounts for approximately 10% of the total export value (KALRO, 2021). Mango production has expanded significantly over the last decade, both in land area and geographic reach. The increasing demand in local, regional, and international markets has driven this growth, making mangoes a crucial income source for smallholder farmers in arid and semi-arid regions (Njenga et al., 2014). Despite the potential for mango farming, post-harvest losses remain a significant challenge, particularly in rural and less developed areas. Mangoes are highly perishable, and losses often translate into lost income. Research by Kitinoja and Al Hassan (2012) identified extreme heat, poor field hygiene, inadequate packaging, and lengthy transit times due to poor infrastructure as major contributors to post-harvest losses of 40–50% of total production. One of the biggest obstacles to agricultural development in Africa is the lack of proper transportation infrastructure. Compared to the worldwide average of 9%, African nations spend an average of 11.4% of their import value on international transportation, this limit the competitiveness of agricultural products, (UNCTAD, 2020). Additionally, tropical mangoes are vulnerable to diseases such as anthracnose and jelly seed infection, further reducing marketability (Brecht et al., 2010). To mitigate losses and extend shelf life, mangoes are processed into various value-added products such as mango flakes, dried mango slices, and mango leather. Research by Ahmed and Ahmed (2012) found that soaking dried mango slices in sugar and

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lime juice preserved their color, flavor, and texture, retaining 53–78% of their original ascorbic acid levels after six months of storage. Apart from the fresh fruit market, mangoes are also processed into juice and dried products, which improve their usability and reduce transportation and storage costs. This has caused a demand growth, a force behind the industry's meteoric expansion in the recent years, (Njenga et, al. 2014). Expanding value addition can enhance profitability for smallholder farmers and increase Kenya's export earnings.

In Kenya, mango growing has a big potential to raise living standards and stimulate the economy. Mango trees are a desirable investment for farmers due to their capacity to flourish in a variety of climates, including dry and semi-arid areas. For instance, recent studies show that Makueni County in Kenya's Eastern Region is leading the way in mango cultivation. With 28,696 farmers and more than 4.3 million mango plants, Makueni County produces over 303,000 tonnes of mangos annually. In 18 of the 30 wards in the county, smallholder farmers are primarily in charge of this production. About 61–80% of Makueni's population participates directly or indirectly in the mango value chain, and more than 30% cultivate mangoes directly, making it vital to the local economy (Alliance bioversity CIAT, 2023). In Kenya, mango farming creates a significant amount of jobs, employing more than 200,000 people yearly along the value chain. These figures demonstrate how crucial mango farming is to maintaining livelihoods and promoting economic activity in rural Kenya (FrointierSIN, 2023).

Even though Kenya's mango sector is growing quickly, little information on the financial performance of each value chain step is available. A significant obstacle to implementing financial interventions in the sector is the lack of knowledge on the financial needs of small-holder farmers, which results in limited financial institution engagement. This is in addition to the inability to optimize the mango value chain by providing the required funding. Although farmers have attempted to decrease post-harvest losses at the early stages of the value chain via their cooperatives, farmers' efforts to process mangos have not been successful.

METHODOLOGY

The study utilized both secondary and primary data. To evaluate how well mango farmers are using agricultural resources, two analytical techniques were employed. These approaches include production function and descriptive statistics. These techniques allow for the evaluation of crucial metrics for resource allocation and economic efficiency. To evaluate efficiency indicators of labor and operation capital, the Cobb-Douglas production function was employed. Inferential statistics was used to calculate the frequency of responses. Statistical Package for Social Sciences (SPSS) software version 30.0 was used to analyze the data. The frequency and distribution of the respondents' demographic and socioeconomic traits was determined using descriptive statistical methods including mode, median, mean, and standard deviation. Descriptive research design was employed to explain the relationship between the dependent and independent variables. The descriptive research design is a type of research that aims to obtain information to systematically describe a phenomenon, situation, or population (Mugenda and Mugenda, 2003).

RESULTS AND DISCUSSION

The Cobb-Douglas production function is the most often applied functional form among those used to analyze the productivity of agricultural inputs (Welsch, 1965). The production function specifies the producer's available production options. It considers how the inputs influence the output. Production function analysis could be used to (1) identify for the farmer the best input combinations that maximize farm incomes, and (2) evaluate the effects on production of specific government policies that affect prices and the amount of resources available to farmers. These applications would be possible if production could be known with certainty, along with information on prices and opportunity costs. However, the extensive set of assumptions required restricts the use of this form of study (Dillon and Hardaker, 1980).

The Cobb-Douglas Production function is specified as follows;

$Y = AX_1\ ß_1X_2\ ß_2$ -------- $X_nß_n\varepsilon$……………………………………………………….(3-1)

OR

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$Y = A * \Pi(Xi^{ßi})$ □ε……………………………………………....………………(3-2)

where: Y represents the quantity of output produced, A is a constant representing the overall productivity or efficiency factor, Xi represents the different inputs (X1, X2, ..., Xn), ßi represents the corresponding elasticity or (regression) coefficient for each input Xi, and Π represents the product symbol, indicating the product of all the terms and ε□is a multiplicative stochastic error or residual term.

When linearized using the natural logarithms, the function takes the form of: -

$lnY = lnA + ß_1 lnX^1 + ß_2 LnX^2 + ... + ß_n lnX^n + ln\varepsilon$…………………..…………..……..(3-3)

OR

$ln(Y) = ln(A) + \sum(\alpha * ln(I)) + ln\varepsilon$…………………..……………………………(3-3b)

where: lnY represents the quantity of output produced; lnA is a constant representing the overall productivity or efficiency factor; $X_{1=}$ Production Cost, $X_{2=}$ Market Channel, $X_{3=}$ Variety, $X_{4=}$ Extension services, $X_{5=}$ Management Strategy, $X_{6=}$ Value Addition, $X_{7=}$ Size of land, $X_{8=}$ Access to Credit; ßi represents the corresponding elasticity or (regression) coefficient for each input Xi, and ∈ is a multiplicative stochastic error or residual term.

Testing of Hypotheses under Production Function Analysis

The two hypotheses were tested as follows:

The hypothesis to determine the farmers' level of efficiency in utilizing the identified resources.

Dependent Variable: Mango Production (in kg or tons) and Independent Variables: Land Size (in acres), Labor (in person-days), Fertilizer Usage (in kg), Irrigation (binary: 1 for irrigated, 0 for rain-fed), and Integrated Pest Management - IPM (in expenses).

$Yprod = \alpha + \beta1 (LandSize) + \beta2 (Labor) + \beta3 (Fertilizer) + \beta4 (Irrigation) + \beta5 (PestManagement) + vi - ui$

OR

$Yprod = \beta0. LandSize^{\beta1} . Labor^{\beta2} . Fertilizer^{\beta3} . Irrigation^{\beta4} . IPM^{\beta5} . n^{\beta.}\ u$

Where:

- Yprod = Mango production (kg or tons)
- LandSize = Land used for mango farming (acres)
- Labor = Person-days of labor used
- Fertilizer= Quantity of fertilizer applied (kg) per acre
- Irrigation = Dummy variable (1 for irrigated, 0 for rain-fed)
- PestManagement = Expenses on integrated pest management
- vi = Random noise/error (assumed to follow a normal distribution)
- ui = Inefficiency term (one-sided, representing deviations from the production frontier)

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To determine which of the identified resources significantly influences mango production.

Dependent Variable: Mango Production (in kg or tons), Independent Variables: Land Size (in acres), Labor (in person-days), Fertilizer Usage (in kg), Irrigation (binary: 1 for irrigated, 0 for rain-fed), and Integrated Pest Management (in expenses).

1. Linear Functional Form:

Yprod= α + β1 (LandSize) + β2 (Labor) + β3 (Fertilizer) + β4 (Irrigation) + β5 (PestManagement) + ϵ

OR

2. Cobb-Douglas Production Function (Log-Linear Form):

lnYprod = α + β1ln (LandSize) + β2ln (Labor) + β3ln (Fertilizer) + β4ln (Irrigation) + β5ln (PestManagement) + ϵ

Using a multiple regression approach: Yprod= β0 + β1 (LandSize) + β2 (Labor) + β3 (Fertilizer) + β4 (Irrigation) + β5 (PestManagement) + ϵ

Dependent Variable (Yprod): Mango production (kg or tons).

Independent Variables:

- **Land Size** (in acres)
- **Labor** (in person-days)
- **Fertilizer** (in kg)
- **Irrigation** (binary: 1 for irrigated, 0 for rain-fed)
- **Pest Management** (expenditure in currency)

The socio-demographic composition of respondents

Mangoes were the main crop of interest in this study. A total of 257 farmers were interviewed, comprising 137 respondents from the Kitui region and 120 from Mwingi region of Kitui County. From our random sample, there was no dominance of either gender in in Mango production. In general, all genders were equally participating in mango production. However, in the Kitui region, there was slight domination by male, contrary to Mwingi region where females had slight domination (Table 3.1). Most of the mango production happened in smallholder production systems. Land sizes ranged from a minimum of 1 acre to a maximum of 20 acres. The mean acreage (SD) of land was 2.57 ± 2.26. The land size of Kitui was slightly larger than those of Mwingi. Almost all farmers (94.2%) were land owners, the rest utilized land under a lease agreement, communal land, family land, or joint ownership in cooperatives. A larger proportion of land lessees and other forms of ownership were found in Kitui compared to Mwingi. The majority of farmers (84.4%) were highly dependent on farming incomes alone i.e. crop and livestock production as their main source of income and only a few had diverse business, employment, and others. The majority of respondents were married in their mid-forties having household sizes ranging between 4-7 members (Table 3.1).

Table 3.1 Socio-Demographic Profile of Respondents Interviewed in Kitui County

Variables: Gender (%)	**Kitui N=137**	**Mwingi N=120**	**Overall mean N=257**	**Significance**
Male	54.0%	45.0%	54.0%	*X^2 =2.08, DF=1, P=0.149*
Female	46.0%	55.0%	50.2%	
Land size (Acres)	2.84	2.26	2.57	*X^2 =15.93, DF=11, P=0.080*
Land ownership (%)				

Owner	91.3%	97.5%	94.2%	
Lease	3.6%	1.7%	2.7%	*X^2 = 4.95, DF=2, P=0.083*
Other	5.1%	0.8%	3.1%	
Main income source (%)				
Farming alone	84.7%	84.2%	84.4%	
Farming and business	11.7%	10.8%	11.3%	*X^2 =.031, DF=2, P=0.926*
Business and other	3.6%	5.0%	4.3%	
Household size (%)				
(0-3)	29.9%	32.5%	31.1%	
(4-7)	65.0%	62.5%	63.8%	*X^2 =0.198, DF=2, P=0.929*
(7Plus)	5.1%	5.0%	5.1%	
Education Level (%)				
None	1.5%	8.3%	4.7%	
Primary	41.6%	30.8%	36.6%	
Secondary	48.9%	58.3%	53.3%	*X^2 =16.30, DF=4, P=0.001*
College	7.3%	0.8%	4.3%	
Informal & Others	0.7%	1.7%	1.2%	
Age (%)				
(18-35)	26.3%	32.5%	29.2%	
(36-60)	70.8%	66.7%	68.9%	*X^2 =2.44, DF=2, P=0.304*
(60Plus)	2.9%	0.8%	1.9%	

Source: Authors, 2024

Assessment of Mango varieties cultivated in Kitui County

A general assessment of the total number of local and exotic varieties cultivated in Kitui shows that more exotic varieties were adopted compared to local ones (Table 3.2). The mean (S.D.) number of local trees was 13.07 ± 22.51 compared to 24.47 ± 33.36 for exotic trees; this difference was significant (*X^2= 4974.81, DF=3536, P<0.001).*

Table 3.2 Analysis of local and exotic varieties of mangoes grown in Kitui

Tree (%)	**KITUI N=137**	**MWINGI N=120**	**MEAN N=257**	**SIGNIFICANCE**
Local trees (Counts)	18.16	7.27	13.08	*X^2= 60.91, DF=52, 0.186*
Exotic tree (Counts)	35.27	12.15	24.47	*X^2=102.37, DF=68, P=0.004*

The number of exotic trees in the Kitui region was larger compared to Mwingi. The quantities of local varieties were similar in Kitui and Mwingi. The mean price (S.D.) of local varieties (22.83 ± 8.24) was lower than that of exotic varieties (32.74 ± 8.26), and this difference was significant (*t=44.37, DF=256, P<0.001*). The dominant local varieties were Ngowe and Dodo, and Boribo and Batawi are the least preferred varieties in Kitui (Table 3.3).

Table 3.3 Mean number of local varieties of Mangoes cultivated in Kitui

Variety	Minimum	Maximum	Mean	S.E.	SD
Ngowe	0	56	5.10 A	0.570	9.14
Dodo	0	50	4.59 A	0.575	9.21
Boribo	0	50	2.42 B	0.346	5.53
Batawi	0	50	0.96 C	0.243	3.90

Means followed with different alphabet(s) are different at 95% C.I.

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The apple variety was the most preferred variety, followed by Tommy and Kent. The least observed varieties were Vandyke and Keit. The apple variety is a conventional exotic that was introduced in Kitui much earlier than the other newcomers, whose adoption needs to be improved.

Table 3.4 Mean number of exotic varieties cultivated in Kitui

Variety	Minimum	Maximum	Mean	S.E.	SD
Apple	0	155	14.44 A	1.39	22.35
Tommy	0	34	3.54 B	0.37	5.97
Kent	0	40	4.83 B	0.48	7.70
Vandyke	0	34	1.05 C	0.25	4.01
Keit	0	10	0.62 D	0.11	1.79

Means followed with different alphabet(s) are different at 95% C.I.

The size of the land did not significantly relate to the number of local trees ($F=0.700, DF=52, P=0.936$) or exotic trees ($F=0.75, DF=68, P=0.910$) found in farms.

Assessment of Pest Management strategies employed by Mango farmers in Kitui County

A minority (4/10) of mango farmers applied integrated methods of pest management, and the majority applied other management options. It was evident that a larger proportion of Mwingi farmers applied no management methods to mitigate the harmful effects of pests. This category (None/No action) was dominant with the local varieties grown for subsistence purposes as opposed to commercialization. Most farmers in Kitui were sales-driven, as implicated by their large dependence on chemicals and profit-margins compared to Mwingi (Table 3.5).

Table 3.5 Management strategies employed by Mango farmers in Kitui County

Management (%)	**KITUI N=137**	**MWINGI N=120**	**MEAN N=257**	**SIGNIFICANCE**
IPM	40.1%	34.2%	37.4%	
Biological	15.3%	20.0%	17.5%	
Chemical	34.3%	16.7%	26.1%	$X^2=21.09, DF=3, P<0.001$
None	10.2%	29.2%	19.1%	

It was observed that the majority of farmers growing exotic varieties formed the largest proportion of farmers applying IPM and chemicals alone. On the other hand, the farmers growing local varieties formed the largest proportion of farmers who were taking no mitigation steps in pest control (Table 3.6)

Table 3.6 Variety influence of Management Options on Mango farmers in Kitui County

Management (%)	**Both N=109**	**Grafted N=96**	**Local N=52**	**Mean N=257**	**Significance**
IPM	44.0%	47.9%	3.8%	37.4%	$X^2=86.57,$
Biological	16.5%	11.5%	30.8%	17.5%	$DF=6,$
Chemical	30.3%	31.3%	7.7%	26.1%	$P<0.001.$
None	9.2%	9.4%	57.7%	19.1%	

The education level of farmers significantly influenced their choice of management strategies. The majority of farmers under IPM had attained college education, and the group was composed of farmers with college education. On the other hand, two-thirds of all farmers who applied no management strategy had never attended school (Table 3.7)

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Table 3.7 Education level influence on Management Options on Mango farmers in Kitui County

Management (%)	**College N=11**	**None N=12**	**Other N=3**	**Primary N=94**	**Mean N=123**	**Significance**
Biological	27.3%	0.0%	66.7%	11.7%	21.2%	$X^2=32.87,$
Chemical	18.2%	25.0%	0.0%	30.9%	24.1%	*DF=12,*
IPM	36.4%	8.3%	33.3%	44.7%	35.0%	*P=0.001.*
None	18.2%	66.7%	0.0%	12.8%	19.7%	

The age of farmers had a very slight influence on the choice of management strategy (Table 3.8)

Table 3.8 Age influence on Management Options on Mango farmers in Kitui County

Management (%)	**60 plus years N=5**	**18-35 years N=75**	**36-60 years N=177**	**Mean N=257**	**Significance**
Biological	20.0%	24.0%	14.7%	17.5%	$X^2=10.77,$
Chemical	20.0%	13.3%	31.6%	26.1%	*DF=6,*
IPM	40.0%	44.0%	34.5%	37.4%	*P=0.096.*
None	20.0%	18.7%	19.2%	19.1%	

Gender had slight influences on the choice of management options. Both genders subscribed to IPM at equal measure. However, more females were classified as biologicals only, and more males were classified as chemicals. This difference was significant at the 90% confidence level (Table 3.9)

Table 3.9 Gender influence on Management Options on Mango farmers in Kitui County.

Management (%)	**Female N=129**	**Male N=128**	**Mean N=257**	**Significance**
Biological	20.2%	14.8%	17.5%	$X^2=7.09,$
Chemical	19.4%	32.8%	26.1%	*DF=3,*
IPM	38.0%	36.7%	37.4%	*P=0.069.*
None	22.5%	15.6%	19.1%	

Assessment on the level of Adoption of Value Addition.

The majority (2/3) of farmers did not introduce value addition components to mangoes before consumption or marketing. Most farmers were selling and consuming their mangoes as raw products, compared to a few (1/3) who converted the product into juice, deserts (slicing), dried mangoes, or a combination (Mixed) of any of the two. There was no difference in application of value addition across wards (Table 3.10)

Table 3.10 Adoption of value addition by Mango farmers in Kitui County

Value addition (%)	**KITUI N=137**	**MWINGI N=120**	**MEAN N=257**	**SIGNIFICANCE**
Dried mango	8.0%	3.3%	5.8%	
Juice	17.5%	13.3%	15.6%	$X^2=6.19$, *DF=4,P=0.185*
Mixed	2.9%	5.0%	3.9%	
Raw mangoes	62.8%	73.3%	67.7%	
Slicing	8.8%	5.0%	7.0%	

The major value addition was the conversion of ripe mangoes into juice, which was done with the assistance of farmer cooperatives, which provided this facility to farmers and were responsible for marketing produce on behalf of farmers Figure 3.1

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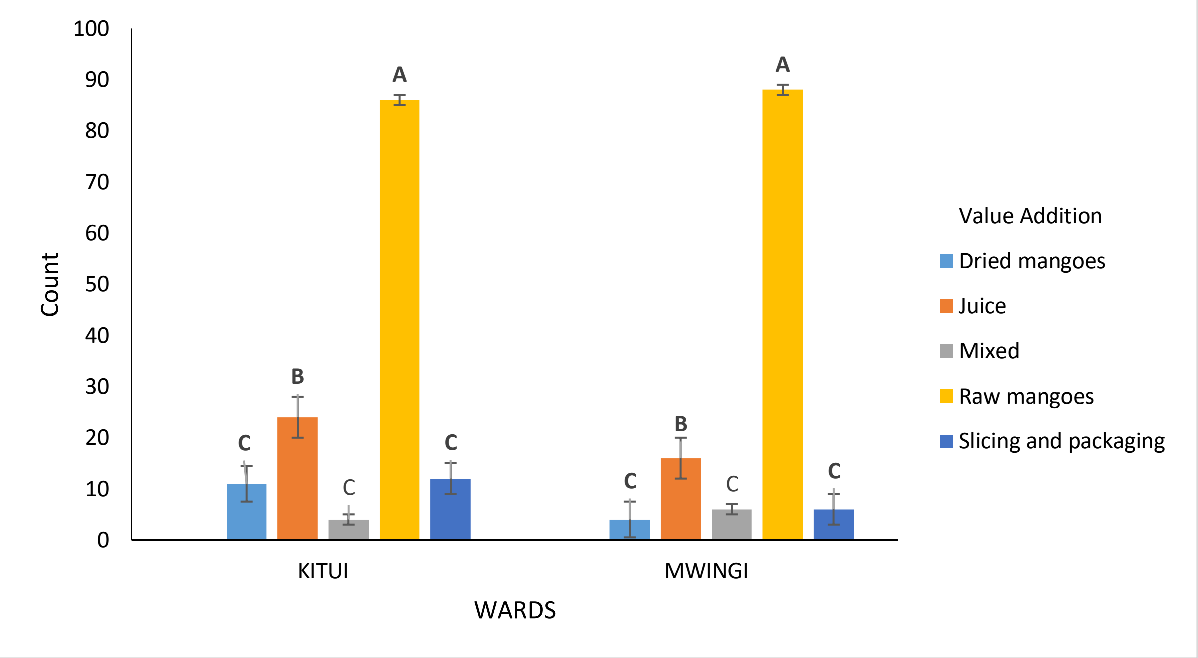
Figure: 3.1 Bar graph showing value addition adopted by mango farmers in Kitui



Key: Bars with different alphabets within a region have count means that are different at 95%C.I.

Few farmers had the individual capabilities to dry mangoes before sale. This drying was mostly done by the sun and not by solar panels. The value addition was highly dependent on the proximity and registration of farmers near a locality to these farmer groups. It was evident that value addition was not dependent on the gender of the respondent *(X^2=5.29, DF=4, P=0.259), age (X^2=4.47, DF=8, P=0.812)*, or variety of mango grown *(X^2=1.20, DF=8, P=0.142).*

Farmers were asked what the main problems encountered in value addition were. They were asked to give a score (strongly agree - 4, agree - 3, disagree - 2, strongly disagree - 1) on various aspects they perceive hinder the adoption of value addition. Lack of awareness of benefits was the main reason for the lack of value addition in Kitui, while the lack of the technologies to be applied was the main reason in Mwingi. In both regions, the lack of farmers to organize in self-help groups received the last score.

Figure 3.2 Bar graph of farmer perspectives of factors hindering value addition in Mwingi

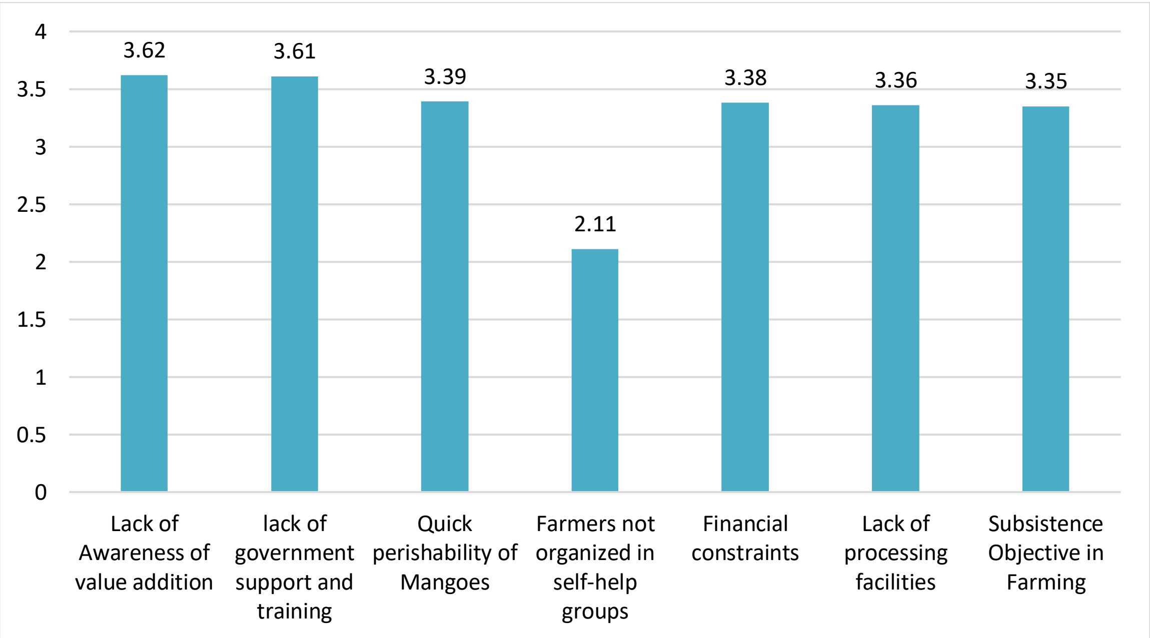


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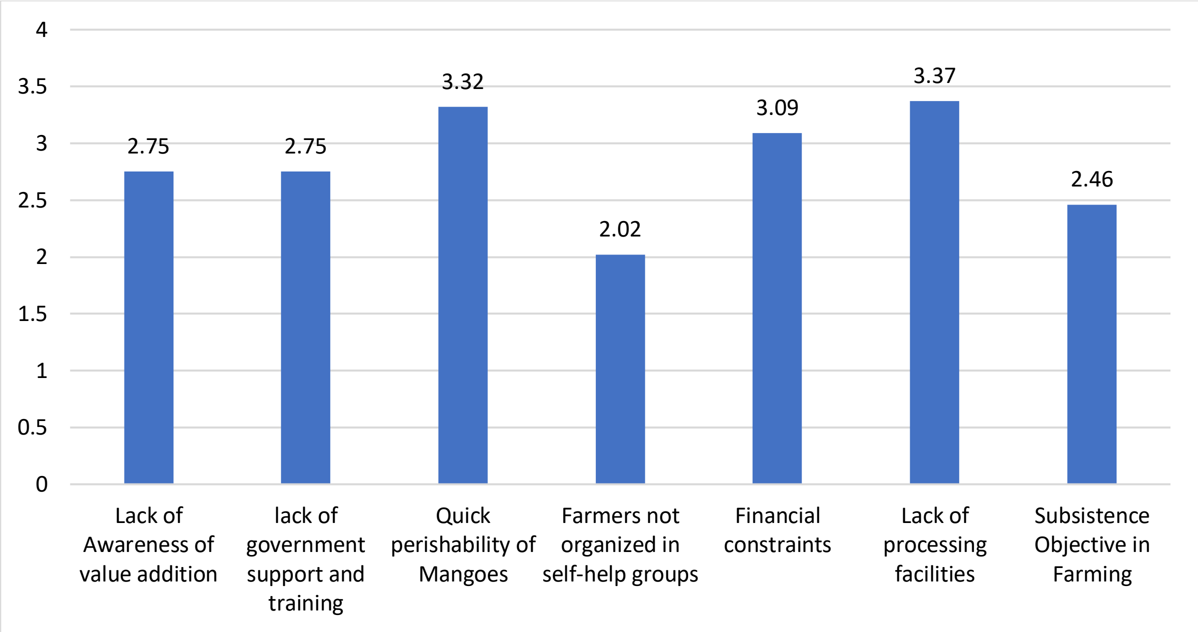
Figure: 3.3 Bar graph of farmer perspectives of factors hindering value addition in Kitui



Access to extension services

Most farmers (7/10) lacked access to extension services. Farmer's accessed extension services from NGOs, farmer cooperatives, and the government. However, NGOs, followed by farmer cooperatives, carried out the majority of extension services compared to government extension officers at county levels. Most farmers received extension services on a quarterly basis in Kitui compared to Mwingi, where extension services were offered on a monthly basis (Table 3.9).

Table 3.11 Frequency of extension services offered in Kitui County for Mango producers

Frequency of extension	**KITUI N=137**	**MWINGI N=120**	**MEAN N=257**	**Significance**
Monthly	4.4%	15.0%	9.3%	*X^2=29.34,*
Quarterly	22.6%	2.5%	13.2%	*DF=3,*
Weekly	3.6%	7.5%	5.4%	*P<0.001.*
Zero	69.3%	75.0%	72.0%	
Extension services providers:	**KITUI N=42**	**MWINGI N=30**	**MEAN N=72**	**Significance**
Government/Counties	5	4	4.58	*X^2=0.03,*
NGOs	24	17	21.08	*DF=2,*
Farmer cooperatives	13	9	11.33	*P<0.982.*

The regression model yielded significant insights, accounting for 71% of the variance in revenue generation and identifying critical areas for interventions to enhance farmer profitability.

Table 3.12 Regression Coefficients of factors affecting Mango production

	B	STD ERROR	BETA	t	P VALUE
(Constant)	-27273	48299.812		-0.565	0.003
Size of Land	-3157.4	3546.144	-0.046	-0.89	0.374
Revenue of local variety	0.542	0.382	0.122	1.422	0.156
Revenue of exotic variety	0.865	0.069	0.725	12.544	<.001
Grand variable cost	1.134	0.224	0.302	5.068	<.001
Total number of Trees	760.595	165.603	0.276	4.593	<.001
Region (Mwingi = 0)	45729.4	16859.657	0.167	2.712	0.007

Gender (Male=0)	-1019.4	17063.688	-0.004	-0.06	0.952
HH size Above7 (below 4 =0)	84432.1	40629.818	0.136	2.078	0.039
Household size 4to7	6308.29	18528.833	0.022	0.34	0.734
Education-Primary (None=0)	53651.6	41920.221	0.19	1.28	0.202
Education-Secondary	33598.8	41168.724	0.123	0.816	0.415
Education-College	3121.06	57082.388	0.005	0.055	0.956
Education-Other	15181.7	88271.308	0.012	0.172	0.864
Age (36-60years) (18-35years=0)	15702.3	18838.666	0.053	0.834	0.405
Age (60plusyears)	-31403	63153.365	-0.032	-0.497	0.619
Pest MGT-Chemical (None=0)	41470.1	25186.618	0.134	1.647	0.101
Pest MGT-Biological	16746.8	27665.335	0.047	0.605	0.545
Pest MGT-IPM	76313.8	23524.839	0.271	3.244	0.001
Value addition-Juice (Dried=0)	-22456	41120.147	-0.06	-0.546	0.585
Value addition- Slicing and pack	-5592.8	47481.455	-0.01	-0.118	0.906
Value addition - Mixed	-75232	55446.394	-0.107	-1.357	0.176
Value addition –Raw Mangoes	-59232	36547.661	-0.203	-1.621	0.056
Extension-Quarterly (None=0)	36690.4	25420.545	0.091	1.443	0.15
Extension-Monthly	-16977	29557.641	-0.036	-0.574	0.566
Extension-Weekly	-39999	37762.851	-0.067	-1.059	0.291
Channel-Gate sale=0	15302.2	27004.559	0.056	0.567	0.571
Channel-Marketing groups	56698.9	29179.517	0.181	1.943	0.053
Chanel-Contractual sales	28927.6	40345.52	0.053	0.717	0.474
Chanel-External brokers	110091	35190.973	0.248	3.128	0.002
R2=0.71, adjusted R=0.47, Durbin-Watson-1.95					

CONCLUSION AND RECOMMENDATIONS

Conclusion

Exotic vs Local Varieties in Kitui Mango Farming

It was discovered that a large number of farmers in Kitui were farming exotic mango varieties, with a preference for traditional kinds over newly enhanced exotic species. This pattern indicates that, while farmers are willing to explore new solutions, they prefer to avoid ones that are not yet generally known for their dependability. Disease-resistant traditional apple mango types are the most popular among exotic kinds owing to their hardiness and familiarity. indigenous varieties, such as Dodo and Ngowe, were the leading traditional choices, demonstrating that, despite the arrival of foreign species, indigenous mango varieties remain popular in the region.

Smallholder Farmers and Resource Restraints

The bulk of mango production in Kitui is managed by smallholder farmers. These farmers are unable to spend much in post-harvest value addition due to severe resource constraints. Many thus depend on selling raw mangoes, which has much smaller profit margins. For example, selling dried mangoes may bring in more than three times as much money than selling raw fruit, according to research. Nonetheless, most farmers continue to employ antiquated sun-drying processes rather than more effective and regulated ones. Despite being more efficient, solar drying is underused because not everyone has access to the right tools or knowledge.

Value addition in Mango Production

Notwithstanding the evident financial advantages of value addition, the majority of farmers in Kitui were not participating in these techniques. Value addition, including the processing of mangoes into goods such as dried mango slices, mango juice, or mango pulp, provides farmers with the possibility to substantially enhance their revenue by accessing more profitable markets. Nonetheless, many limitations impede the extensive use of value addition approaches.

The primary obstacles are insufficient awareness and inadequate facilities. Numerous smallholder farmers are oblivious to the economic advantages that value addition may provide. Moreover, the resource limitations encountered by these farmers hinder their ability to invest in essential infrastructure for value-added processing (Onamu et al., 2024). The majority of farmers persist in use conventional sun-drying techniques for mangoes, which fail to attain the requisite low moisture content demanded by export markets and are less effective regarding time and quality (Osunde, 2017). Solar drying technology, which offers superior efficiency and the potential for higher-quality dried mango products, is underused owing to limited access to the necessary technology and funds for acquisition.

Recommendations

Creating Centers for Certified Propagation: Research stations like the Kenya Agricultural and Livestock Research Organization (KALRO) should be encouraged to set up accredited propagation centers in order to aid in the enhancement of mango varieties in Kitui. With the help of these institutes, farmers would have more cheap access to superior mango types like Kent and Keitt, which are more suitable for both domestic and international markets. Farmers will have better access to these kinds, which will enable them to produce mangoes of higher quality and at higher yields.

Financial Support Via Farmer Associations: Financial support need to go through cooperatives or formalized agricultural groups. With the help of this proposal, farmers would be able to pool their resources and invest in infrastructure that is required, such irrigation systems, solar dryers, and value-added plants. The government may also provide improved extension services and training programs through farmer organizations, which will increase mango production in Kitui.

Financial Support through Farmer Groups: For farmers to overcome financial obstacles, government support is crucial. Financial support need to go through cooperatives or formalized agricultural groups. With the help of this proposal, farmers would be able to pool their resources and invest in infrastructure that is required, such irrigation systems, solar dryers, and value-added plants. The government may also provide improved extension services and training programs through farmer organizations, which will raise Kitui mango producers' total production.

Strengthening the Role of the Private Sector and NGOs: In order to increase mango production in Kitui, the private sector—including farmer cooperatives and non-governmental organizations (NGOs)—should be urged to become involved. As part of their ongoing efforts to combat pests, some NGOs already offer subsidized agricultural inputs including fertilizers and bio-pesticides. Agricultural extension agents may organize farmers and urge them to take advantage of these initiatives, which might further extend their engagement. In order to scale up sustainable agricultural methods and solve the issues smallholder farmers confront, partnerships across the public, commercial, and non-governmental sectors will be essential.

Capacity Building for International Market Access: Gaining access to foreign markets, especially those in the European Union, is one of the most attractive prospects for Kitui mango growers. The Horticultural Crops Directorate (HCD) ought to lead capacity-building programs to make sure farmers are aware of the requirements for export. Kitui farmers might open up new revenue streams by exporting their product by participating in training programs that improve mango quality, insect control, and post-harvest handling. Additionally, efforts should be taken to ensure that Kitui mangoes fulfill the relevant international quality requirements by streamlining the export procedure.

Promoting Adoption of Integrated Pest Management (IPM): Lastly, it is imperative to encourage Kitui farmers to implement Integrated Pest Management (IPM) techniques. To manage pests sustainably, this strategy would combine biological, cultural, and chemical control techniques. Farmers may increase both the environmental sustainability of their agricultural operations and the quality of their mango crop by lowering their need on chemical pesticides. Agricultural extension services should include IPM training as a basic component, and farmers should be made aware of the methods' advantages—both ecologically and economically.

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