Socio-Economic and Physical Factors Affecting Mango Performance and Productivity in Makueni County, Kenya

Dominic Kioko, Prof. Okeyo Benards (Phd), Prof. Mohamed K. Timamy (Phd)

Department of Environmental Science (Pwani University), Kenya

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ABSTRACT

Mango (Mangifera indica) is one of the most popular fruits in many countries and among millions of people in the world. Mango is an emerging tropical fruit produced in over 90 countries worldwide. Mango production stands at 180-200 pieces per tree against a potential of 500 pieces per tree, necessitating a high demand. This study sought to examine the factors influencing mangos' performance and productivity in the dry lands of Makueni County, Kenya. Across-sectional descriptive research was used and case study of two farms in extreme parts of the county was also deployed. A total of 382 farmers were selected for the study using simple random sampling methods. Purposive sampling was used to get sub-county, ward officers, chiefs, sub-chiefs, elites and village elders for Key Informant Interviews. Quantitative data was analyzed using descriptive statistics such as mean, percentages and modes, regression. Qualitative data was analyzed by creating themes and patterns and then validating the usefulness of the information obtained. The study found that mango was one the major source of livelihoods in Makueni County necessitating increase in acreage under mango cultivation. Findings unearthed, the acreage increased from 46,364 ha to 65,453ha between 2015 and 2021. Overally, mango production and performance were found to be increasing. Introduction of commercial mango varieties which are highly yielding. The varieties which include Tommy Atkins, Kent, Van dyke, Haden and Apple have been widely adopted by farmers and this has led to increase in production levels in Makueni county. Production increased by 29.13% between 2010 and 2021 yearly. However, there were seven major constraints that posed great challenge to the agrarian farmers. Climate change, drought, access to market, land ownership, access to capital, access to technology, pests and diseases and mango species were found to be major constraints affecting mango cultivation. The study found out that the increase in mango productivity and performance was due to majorly an increase in acreage but not really due to good agronomic practices. Therefore, it is recommended that multi agency efforts are highly required to curb the impact of Climate change, drought, access to market by incorporating appropriate post-harvest technologies such as storage, transport of mangoes to ensure production doesn't decline. Post –harvest behaviors of different cultivars of mango on their shelf life should be explored to improve performance and productivity of mango.

Keywords: Mango (Mangifera indica) Performance, Productivity, Socio -Economic and Physical Factors, Makueni County

INTRODUCTION

Mango (Mangifera indica) is an emerging tropical fruit produced in over 90 countries worldwide (FAOSTAT (2011). Globally, the cultivated area under Mango tree covers an approximate area of 4946 thousand hectares with a production of 37.12 million tons in 2010 (FAO, 2011-12). Nevertheless, mango production is performing poorly standing at 180-200 pieces per tree against a potential of 500 pieces per tree (Khatun, 2020). The decrease in production has been attributed to climate change, drought, resurgence of pests and diseases, market dynamics, technological change and government policies.

In Kenya, mango is grown in relatively dry area. Kenya Agricultural Research Institute (KARI) has for the last 20 years introduced commercial mango varieties which are high yielding. Such varieties which include Tommy Atkins, Kensington, Van dyke, Haden and Apple have been widely adopted by farmers and this has led to increase in production levels especially in Eastern, Coast and Central Provinces (Gitonga et al 2009). This has

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seen the area under mango cultivation in Kenya rise from 500 ha in 1970 to approximately 30,000 ha in 2008 (MoA, 2009). Mango production has risen from approximately 254,000 tonnes with a value of Ksh 3.1 billion in 2005, to a production of 448,000 tonnes, with a value of Ksh 6.4 billion in 2008 (HCDA, 2008). The semi-arid Makueni County is leading in mango production in Kenya with a total of 4,311,375 mango trees grown by 109,465 farmers. The area under mangoes in Makueni increased from 6,721 ha to 11,574 ha between 2011 and 2012 leading to an increase in production from 60,396 tons to 138,887 tons. Similarly, the value increased from Kshs 2,272 to 2,778 million in the same period (HCDA, 2012). According to the Institution of Development and Management (2010), income from mango farming contributes to about 40% of the households' income in the County. However, mango production and performance in the County has not been consistent with some years experiencing poor performance. Occasionally, harvesting methods as well as post-harvest losses have led to huge economic losses. This paper highlights factors that influence mango performance and productivity in Makueni County.

Objective of the study

The study examined the factors that influence mango performance and productivity in Makueni County between the year 1991 and 2021.

THEORETICAL REVIEW

Theories deployed in the research.

Human Ecological theory was developed in 1920 by sociologists of Chicago Roderick Mc Kenzie and others. It borrows ideas from the field of ecology and analysis the relationship between human with their physical and social environment. The theory proposes that social groups adapt to the ecological struggle for environmental adaptations found in nature. The social groupings and processes include the community (Mc Kenzie, 1971). The theory helps in this research to unravel the factors affecting productivity and performance of mango, local adaptation, mitigation and response practices by mango farmers in Makueni County curbing any ecological struggle in the factors impact.

STUDY AREA AND RESEARCH METHODOLOGY

Makueni County covers an area of 8,008.9 Km^2 and lies between Latitude 1º 35´S and 3º00' S and Longitude 37º10´E and 38º 30´E (Gok, 2019). The County boarders Kajiado, to the West, Taita Taveta to the South, Kitui to the East and Machakos County to the North

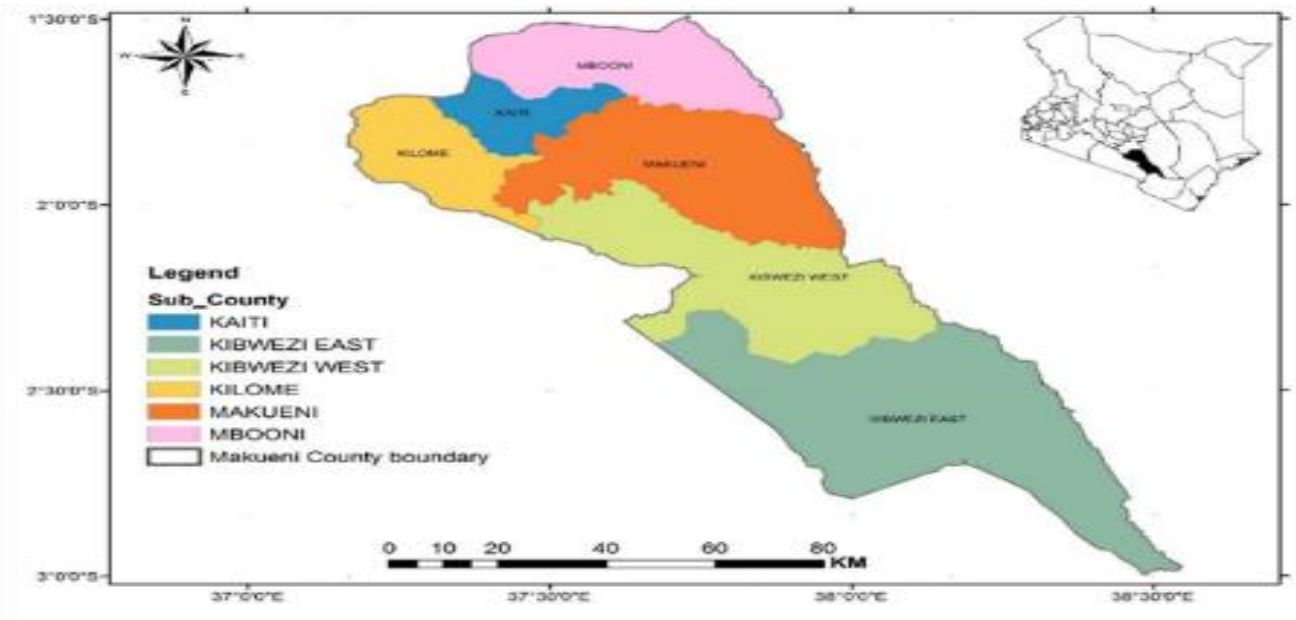

Fig. 1: Map of Makueni County – Kenya

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Makueni county has a population of 987,653 and households of 244,667 with a population density of 120/km^2. Rainfall ranges from 600mm to 897mm.Temperatures are very high above 23^{0}C, high temperatures during the day and low temperatures during the night. The rainfall is characterized by low total amounts, strong seasonal and bimodal distribution (Nyangito et al., 2008). Long rains occur from March to May and short rains from November to December. According to Gichuki (2000) short rains are more reliable this is reliable conditions for mango growing. The economic activities undertaken in Makueni county entails: livestock rearing, fruit growing (mango, fixes, oranges, avocados, pawpaw) cereal growing, brink making, sisal farming. Mango farming is one of the major livelihoods to agrarian farmers of Makueni county thus the key attention to its performance and productivity.

METHODOLOGY

The study used cross-sectional research design where both quantitative and qualitative methodologies were deployed. Further, a case study of two mango farms was undertaken for in depth data. A combination of techniques, both qualitative and quantitative was used to obtain primary data. The research paradigm provided rich and detailed pictures of why people acted in certain ways, climatic dynamics and perspective of people's feelings. Rapid Rural Appraisal (RRA) technique was used to obtain the necessary primary data from mango farmers, extension officers and other experts. The basic principles of action research were also applied.

Sampling

Data was obtained from 380 mango farmers from sixteen mango cluster zones proportionally to their population using household questionnaires and ten key informants using Key Informant Interviews schedules. Multistage cluster sampling technique was used to select respondents in the study site. In stage one, administrative constituencies were clustered. There are six constituencies in Makueni County with 30 wards and finally the 16 mango cluster zones. Stage two was proportionately random sampling to select household respondents from all the 16 mango cluster zones. Mango divisions were identified and from the respective clusters proportionate mango farmers were identified with help of sub chiefs and ward administrators.

Data analysis

Primary data for analyzing socio-economic data collected from the field were analyzed using MS Excel and SPSS. Bar diagram and pie chart were generated after the analysis. The secondary data was analyzed using Arithmetic mean and linear trend. Data obtained through different sources proceeded, analyzed and was interpreted. All the data was analyzed using Microsoft Excel Software.

RESULTS AND DISCUSION

Demographic characteristics

The majority of respondents were female, with 246 (64.7%) identifying as female, while 134 (35.5%) were male. In terms of education, most respondents had only completed primary education, totaling 135 (35.5%), followed closely by those with secondary education, 133 (35.0%), and a smaller portion, 112 (29.5%), had attained tertiary education. Further, a significant portion of respondents, 201 (52.9%), earned less than Ksh 10,000 per month from mango farming during the mango season. However, farmers with at least 3 acres of mango trees earned over Ksh 100,000 monthly during mango season. Additionally, 280 (73.7%) of respondents were involved in crop farming. Results showed that the largest group of respondents, 156 (41.1%), were over 50 years old, followed by those aged 41-50 years, 110 (28.9%), and those aged 31-40 years, 94 (24.7%). Mango farmers' trajectory remained promising in Makueni.

Mango Production since 1991

Mango production and performance in Makueni County varied from one season to the other and from year to year but with an overall increasing trend over the years.

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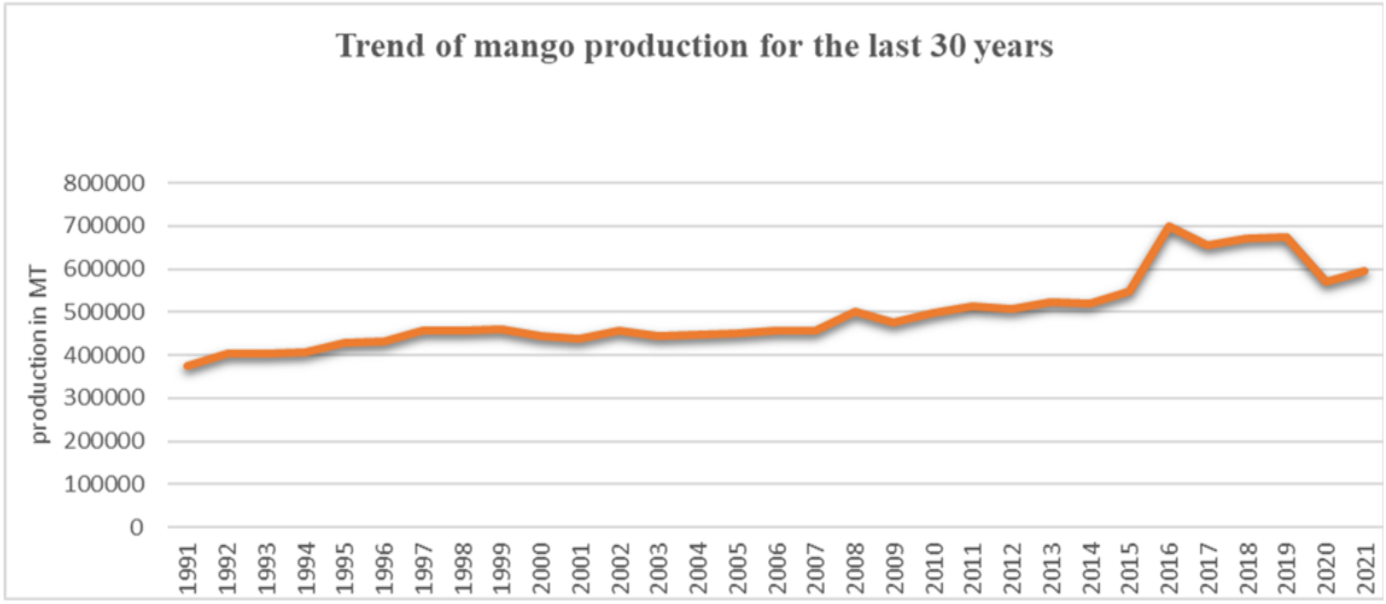

Figure 2: Mango production in Makueni County since 1991-2021

Source: field data

The increase was attributed to an increase in the acreage under mango cultivation. Being among the main sources of income in the study area, farmers endeavor to maintain high production over the years. Owing to the many factors influencing mango cultivation, farmers sustained the high production by increasing the area under mango trees. This section explains the socio-economic and physical factors affecting mango performance and productivity in Makueni County.

Socio-economic and physical factors affecting mango performance and productivity

Mango production and performance varied from one season to the other. This was caused by various factors as shown in Figure 3.

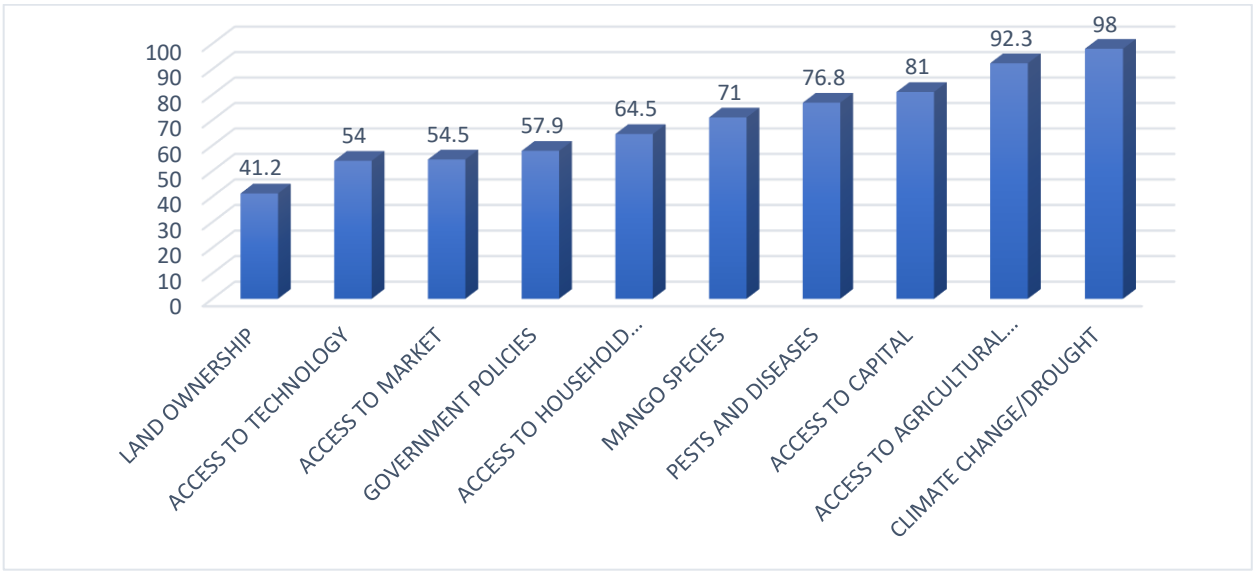

Figure 3: Socio-economic and physical factors influencing mango Performance and Production

Source: Field data 2022

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Climate Change

The changing climate evidence and frequent occurrence of droughts was identified by 98% of the respondents as the major physical factors affecting mango performance and productivity in Makueni county. As a factor, frequent droughts lead to a decrease in mango productivity. Farmers indicated that they had observed a decrease in rainfall as well as increasing temperatures over the years. Their assertion was supported by climate data which showed an increase in temperature (Figure 3).

Temperature

Farmers were asked to provide feedback on the temperature trends over recent years. Table 1 below illustrates a consistent increase in temperatures. Almost all farmers, 378 respondents (99.5%), observed rising temperatures over the past three decades, with less than 1% expressing a different viewpoint.

Table 1. Temperatures have changed in the last 30 years

Temperature change	Frequency	Percent%
Decreasing Temperature	1	0.25
Temperature remained constant	1	0.25
Increasing Temperature	378	99.5
Total	**380**	**100.0**

The qualitative findings presented in Table 1 provide a clear example of the rising temperatures over the past 30 years, beginning in 1991. When mango farmers were asked about the changes in temperature over time, they reported a noticeable increase. Supporting this observation, quantitative data from the Makindu weather station, which has been collected since 1991, shows a consistent rise in temperatures. This increase has led to higher evaporation rates, which, in turn, have depleted the already limited water resources available to the mango trees, placing them under significant stress. As illustrated in table 1, temperatures surpassing 27°C, the ideal range for mango tree growth, resulting in decreased performance and lower productivity of mango.

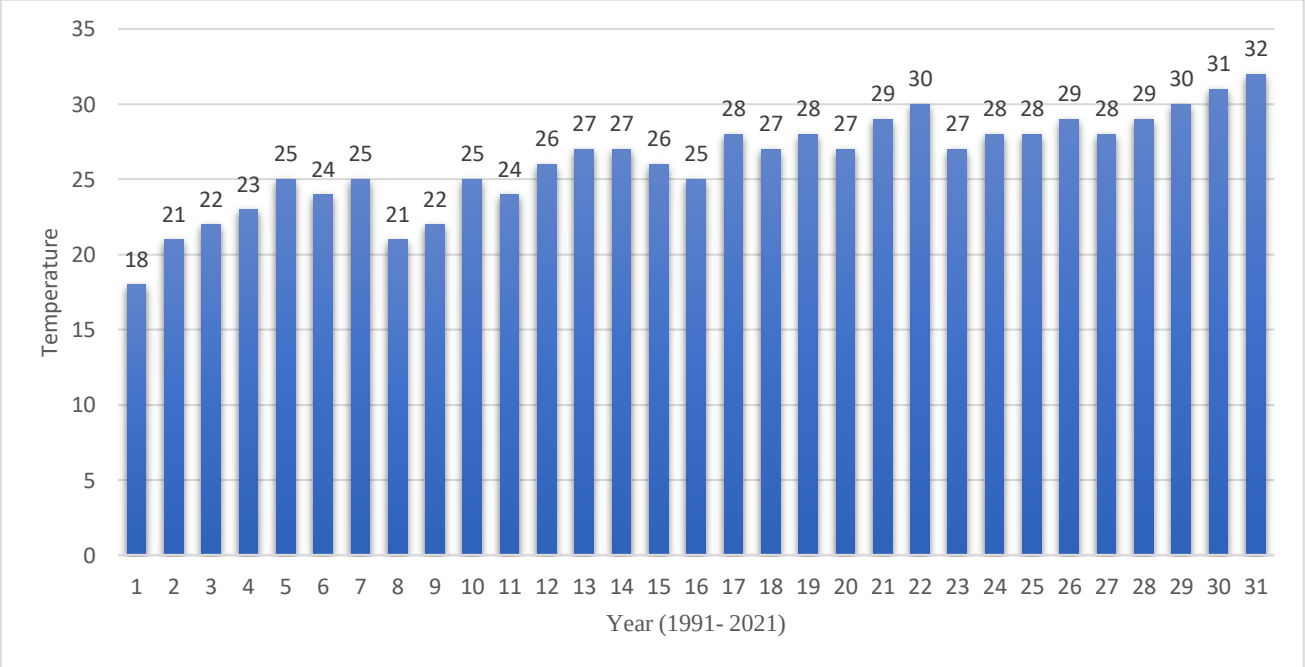

Figure 4: Trend of temperature between 1991-2022

Source: Makindu weather station 2022

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The favorable temperature for mango ranges between 24-27°C during the growing season along with high humidity. However, in some years in the study area, temperature surpassed the recommended range of temperature for optimum mango production. From figure 3, it was evident from the year 2008 – to date temperatures had increased to surpass the required 27°C. This led to low production per mango tree necessitating addition of more trees by farmers to meet the desired production, demand and income. Additionally, diagrammatic representation of rainfall in Makueni was in harmony with both quantitative and qualitative data from key informants, and all indicated reduced rainfall.

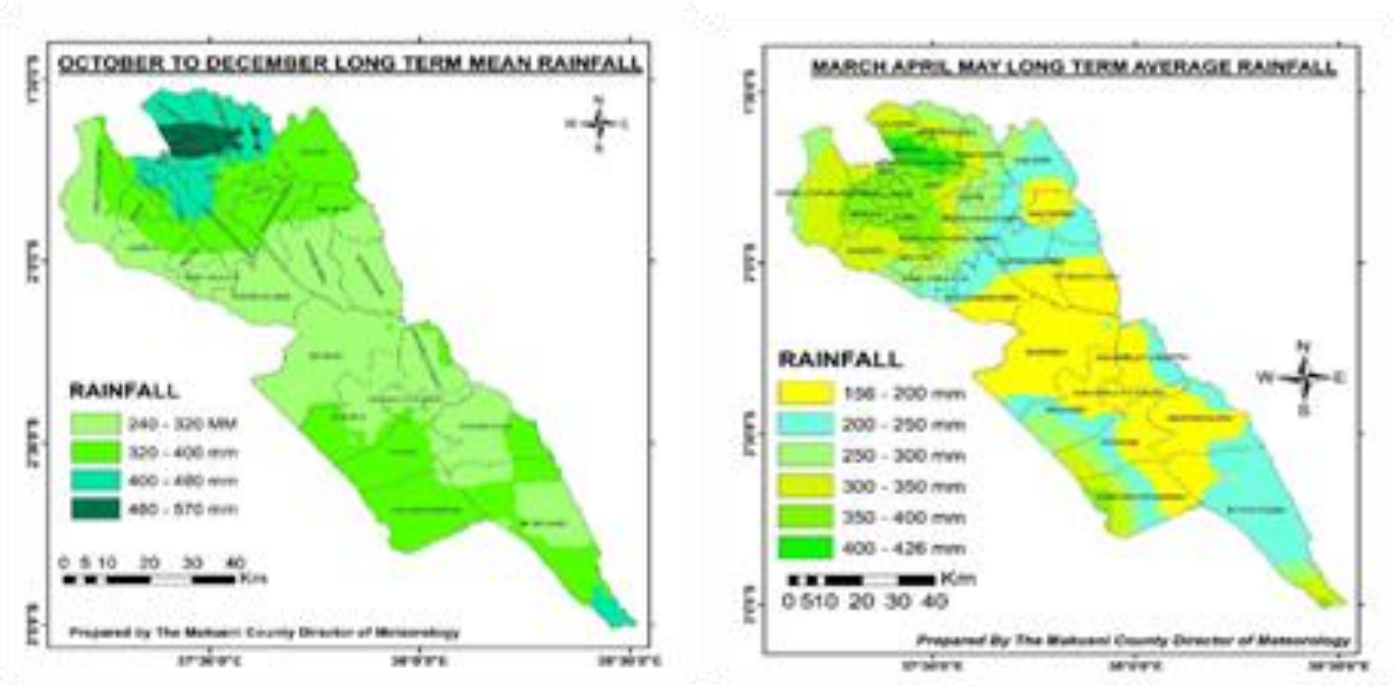

Figure 5: Showing Rainfall Distribution in Makueni County in long rains and short rains

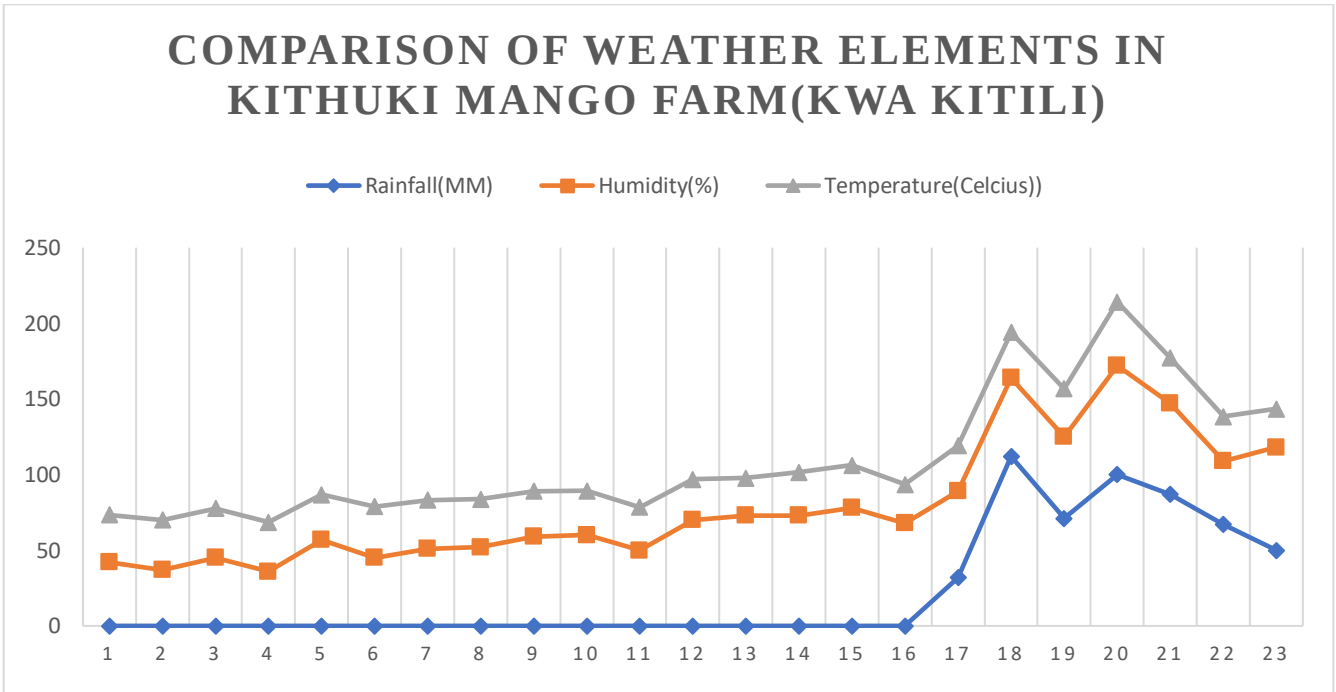

Figure 6: Showing Rainfall Distribution in Makueni County in short rains in the selected farm

The study also established that during the primary growing seasons (October, November and December) large parts of Makueni County received average rainfall of between 240mm - 320 mm. Rainfall of less than 250mm caused strain to mango trees during this period. During the secondary growing season that occurs in March,

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April and May, rainfall ranged between 156mm and 200mm. This was far below the expected amount required for mango trees. Reduced amounts of rainfall during the growing seasons resulted in drying of mango trees, low production and performance.

Access to agricultural training

Access to agricultural training was identified by 92.3% as a factor that influenced mango production and performance. Training on agronomic practices was irregular with only few farmers indicating that they were visited by extension officers in their farms in the last five years. Hence, majority of the farmers relied on the traditional methods of farm management over the scientific modern methods which led to great losses during the post-harvest, storage and transportation of mango fruits to the markets. With lack of training on agronomic practices, farmers sought information from the experienced farmers in their neighborhoods. The experienced farmers were majorly consulted on issues relating to grafting, mango cultivars, Pesticides and pruning services.

Mango farmers were asked to give their view on climatic information, about 54.5% of the farmers had received climate change awareness and its effects on farming activities. Thus, they understood the relationship between performance and productivity of mango and changes in climatic variables. Discussion with extension officers and respondents indicated that understanding of climate change information allowed them to adapt from effect of climate change. This was evident from the climate change adaptation and mitigation measures they had put in place. Where farms where adequate adaptation measures had been put in place, mango production and performance were relatively high.

Pests and Diseases

To understand the influence of pests and diseases in the production and performance of mango, occurrence of pest and disease in the region as well as their frequency of occurrence was analyzed. The study revealed that most about 70.3% of the respondents had their mango affected by pests and diseases.

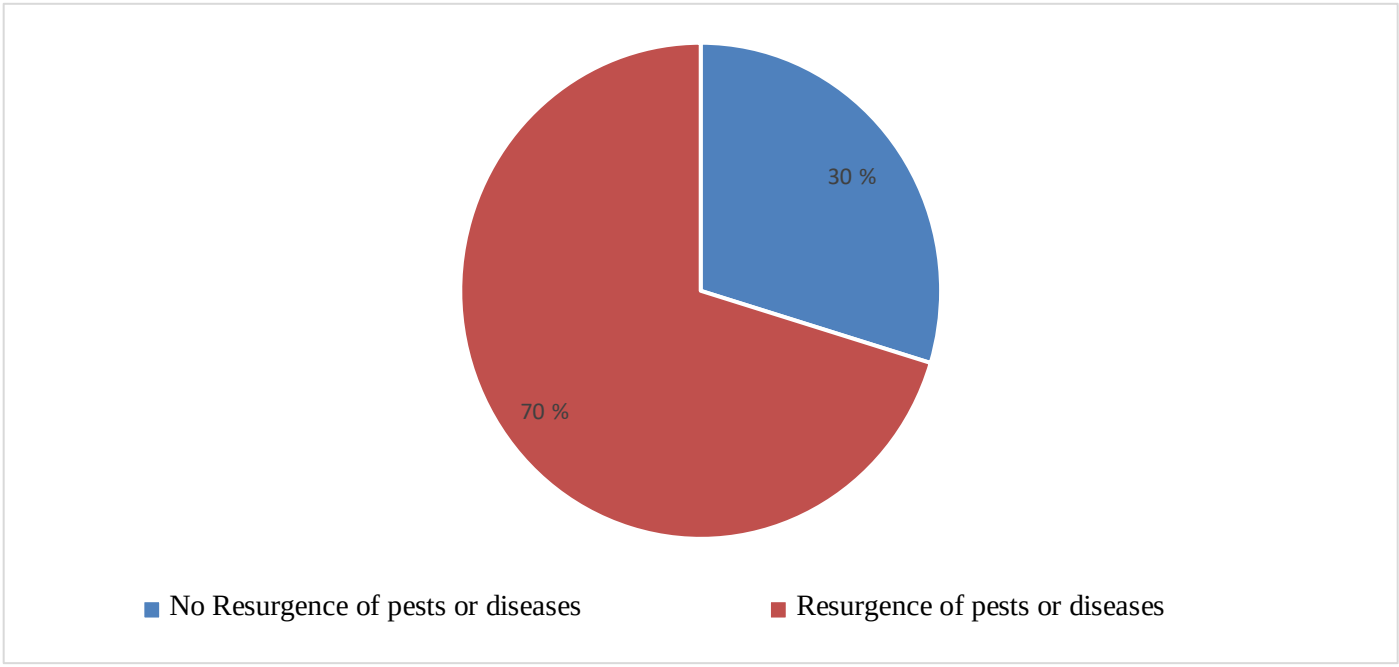

Figure 7: Pests and diseases

Some of the pests and diseases were new in the area and therefore they had limited knowledge of controlling them. Major pests were the fruit fly (Bactrocera invadens), seed weevil (Sternochetus Mangifera), weevils, ants and mealy bugs (Rastrococcus invadens). Diseases like anthracnose and powdery mildew were common in almost all mango growing farms in Makueni. Figure 8 shows some of the pests and their effects on mango trees.

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Plate1.Fruit Fly | Plate 2. Florescence Midge | Plate 3. *Leaves Attacked By White Flies*






Rusting on mango fruits

Figure 8: Some of the pests and their effects on mango

Attacks by pests and diseases degraded quality of the fruits resulted in huge yield losses. However, this increase in production has been accompanied by large postharvest losses of 45% due to limited value addition options during production gluts. The combined impact of the pests and diseases underscores the vulnerability of mango cultivation in Makueni, highlighting the urgent need for integrated pest management strategies, disease-resistant varieties, and farmer education programs to sustain mango production and ensure food security in the region. The pests and diseases have resulted in enormous impacts in Makueni shown under the following aspects.

Government Policy

Agriculture sector is one of the sectors that have been devolved in Kenya and most of the activities that were being controlled from the national level are now controlled at the County level. Policies for agriculture consist of government decisions that influence the level and stability of input and output prices, public investments affecting agricultural production, costs and revenues and allocation of resources. These policies affect agriculture either directly or indirectly. The objectives of agricultural sector strategy have been increasing agricultural growth, seen as important for increasing rural incomes and ensuring equitable distribution. Due to limited availability of high potential land, it has been envisaged that increasing agricultural production will have to come from intensification of production through increased use of improved inputs, diversification especially from low to high value crops, commercialization of smallholder agriculture, and increased value addition through stronger linkages with other sectors. Majority of respondents (57.9%) believed that government policies did not hinder mango production and performance. However, farmers expressed the need for policies aimed at stabilizing input costs, as these costs were continuously rising.

Access to Market

Access to markets by farmers, especially women, remains limited at the local, national, regional, and international levels. Results presented in Figure 9 show that over three quarters of the respondents always experienced an adequate market for their mango products. Moreover, organized markets for mango farmers were far below the general access to markets

Figure 9: Access to market

Source: Field data 2022

This affirms market as one of the barricades to mango production and performance in Makueni County with only 205 (54.5%) being able to access formal markets. Organized markets here meant markets provided by county and national governments, markets by cooperatives and mango processing plant. The data showed 45.5% had Poor or no access to market for mango produce. This trend was associated with inadequate market facilities, high transportation costs due to dilapidated roads, low quality fruits due to poor harvesting and limited storage methods. This was in harmony with the study of ACET, that Trade finance is also widely acknowledged to be a limiting constraint to expanding both intra- and external agricultural export initiatives (ACET, 2014). mango farmers operate in a climate of uncertainty but are not willing to enter formal contracts with farmers; hence farmers do not trust them (Msabeni et al., 2010). Where markets have been heavily infiltrated by brokers, farmers sell their produce at relatively poor prices completely failing to meet the operation costs.

The scope of access to markets in Makueni county was distributed as shown figure 10 below.

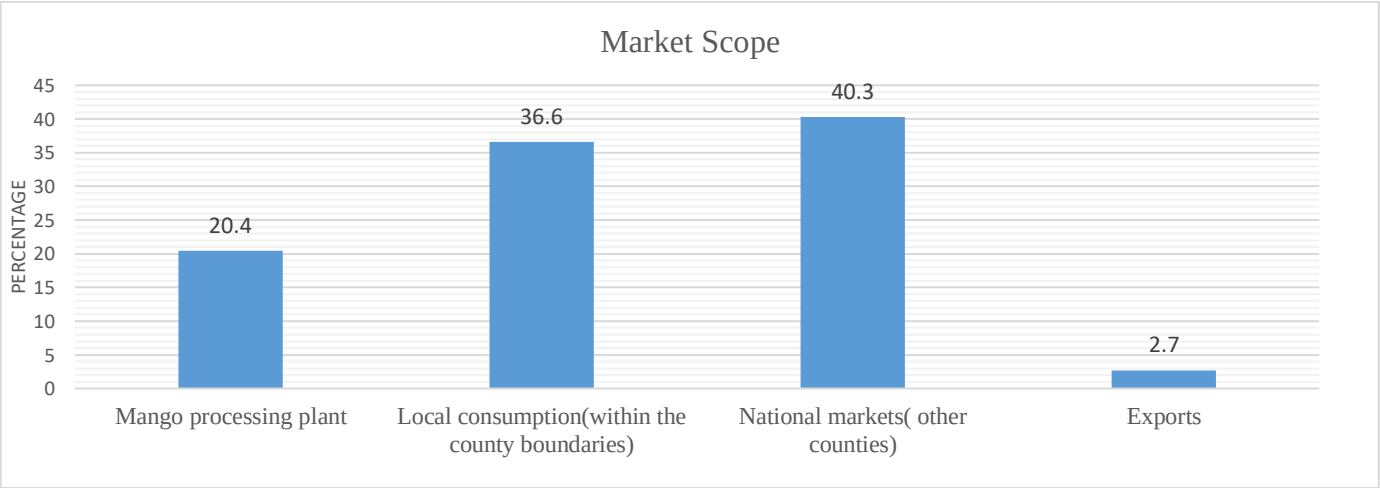
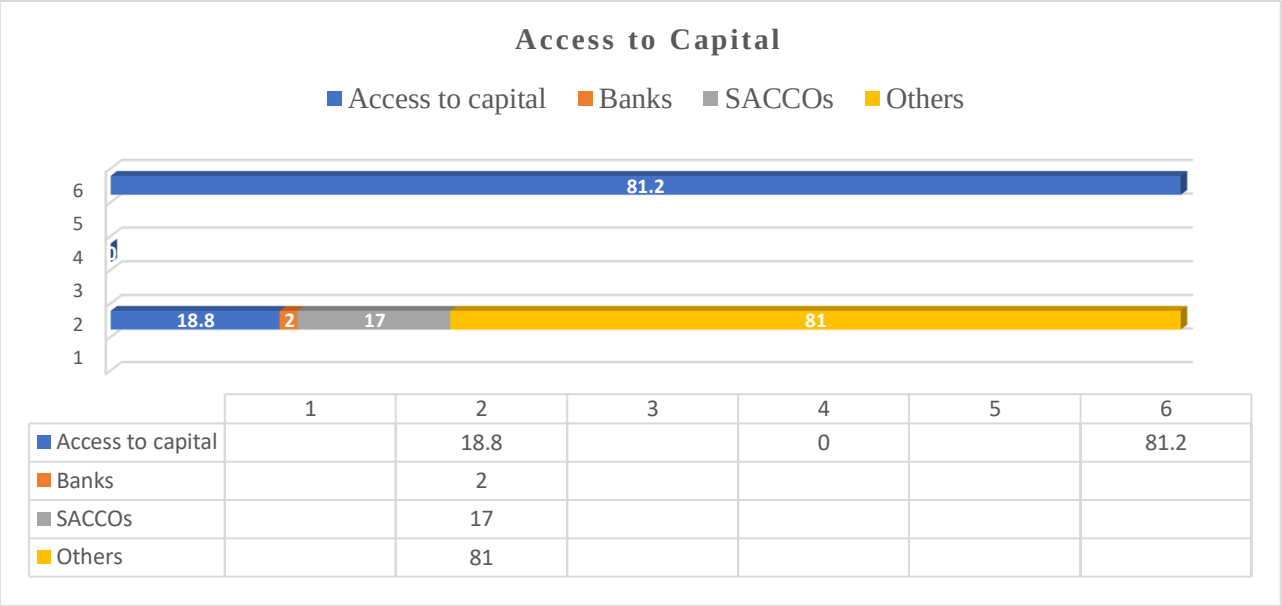


Figure 10: Market scope

Markets varieties were sought from farmers. Farmer indicated they only sold mango to 40.3% of other counties such as Nairobi County and Mombasa County. Makueni mango processing plant consumed 20.4% of produce but under cooperative arrangements. Local consumption and not in the processing plant accounted for 36.6%. Further mango growers admitted that huge portions of their mango crop were sold to brokers at extremely low prices. Most farmers had not joined cooperatives due to the exorbitant membership fees (Ksh 2500-3500).

Access to capital for mango production

Access to finance by mango farmers is ostensibly low. Over 80% of the farmers finance their mango farming activities from their meager savings. Only about 18.8% of the farmers get financial access from Savings and Credit Cooperative (Figure 10)



	1	2	3	4	5	6
Access to capital		18.8		0		81.2
Banks		2				
SACCOs		17				
Others		81				

Figure 11: Access to capital for mango production

Source: Field data 2022

Lack of adequate capital to finance farming activities limits increasing production and investment in value addition activities in agriculture. Opportunities for financing the mango value chain reveals that over three quarters 308(81%) of the respondents confirmed of financing their mango from own farm operations, while 72(19%) indicated that they received finance from cooperates Sacco's such as Kibwezi and Matiliku Saccos. Inaccessibility to credit especially for small scale farmers and especially women has limited the range of activities, the type of technology used and the scale of operations that a farmer can adopt on his farm. The mango farmers' alluded lack and minimal support toward access to credit leading to inability to purchase grafting material thus shortage of grafted seedlings of improved and higher yielding varieties.

Farmers often used inferior seedlings obtained by germinating mango seeds from indigenous varieties. Farmers further indicated such ungrafted trees take much longer to flower and bear fruit. Whereas grafted trees begin to bear fruit within 3 to 4 years as opposed to ungrafted trees which take at least 5 years to bear fruit, depending on other natural constraints. Thus, to improve agricultural productivity and incomes, especially of smallholders most of whom reside in rural areas, access to affordable financial credit is important to enable them to acquire new farming technology - a necessary input in realizing the higher productivity goal.

Mango cultivars

In Kenya, the mango industry has seen significant changes in recent years, blending traditional favorites with modern farming practices. Varieties like Kent, Apple, Ngowe, and Tommy Atkins have long been favored for their resilience to local conditions and familiarity among consumers.

However, there's was a noticeable shift towards cultivating improved breeds such as Haden, Keitt, and Ataulfo. These varieties are gaining popularity due to their exceptional flavor, extended shelf life, and suitability for export markets. This transformation is spurred by rising demand both locally and globally for high-quality mangoes, prompting farmers to adopt advanced agricultural methods. Farmers and key informants alluded that by embracing these improved varieties, farmers not only meet international standards but also enhanced productivity and sustainability of mango.

The respondents' preferences for mango varieties were ranked as follows: Apple topped the list with 156 (41%), followed by Tommy Atkins with 65 (17%), Kent with 63 (16.6%), Ngowe with 53 (14%), Boribo with 10 (2.7%), Vandyke with 9 (2.4%), and others, including Alphonsio, Terpentine, Haden, Sabine, and Sensation, each accounting for less than 2% based on KALRO scientific names

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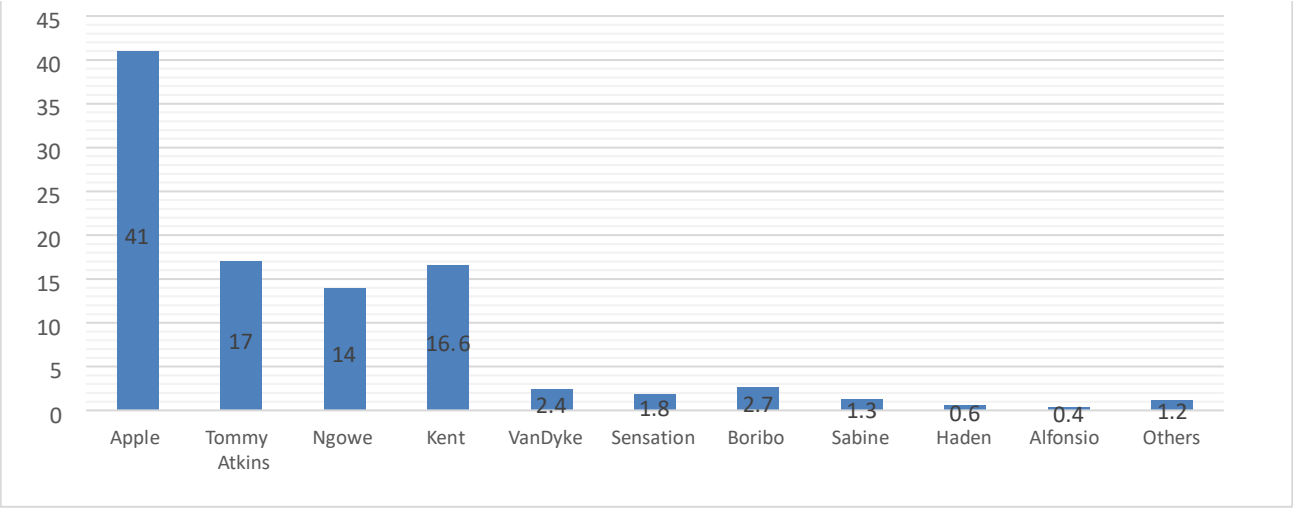

Figure 12: Variety(s) of Mango grown in Makueni farm

The study further revealed that most of these farmers prefer apple cultivars, highlighting the popularity of this variety among mango farmers in the region. The apple mango variety is characterized by medium to large fruits that are nearly round, with a rich yellow/orange to red colour and smooth, thin skin. The juicy yellow flesh is noted for its excellent flavor and melting texture, free from fibre. This cultivar averages 9.7 cm in length, 11 cm in width, and weighs around 397g, placing it in the medium to large category.

Plate1: Mango varieties

The harvesting period for apple mango typically spans from October to March and May to July. Twist to speak, this variety offers several advantages, including superior fruit quality, small to medium seed size, and a lack of fibrous texture. However, apple mangoes are susceptible to diseases such as anthracnose and powdery mildew, as well as alternate season bearing, where yields in one season are influenced by the previous season's production levels (high yielding followed by low yielding seasons and vice versa). It also exhibits limited adaptation to a narrow range of altitudes.

This evolution signaled a promising future for Kenya's mango industry, supported by a diverse array of mango varieties that cater to a diverse consumer preferences and market demands. Overall, qualitative data indicated a shift from indigenous varieties and less resistant cultivars by farmers and embracing more improved and preferred mango varieties.

Access to technology

According to the findings on technology use in mango production, respondents indicated that 267 (70.3%) of new technology was being used in mango farms. Additionally, 113 (29.7%) of respondents indicated the use of cultural practices to prevent mango attacks by pests and diseases. The cultural practices included springling ash on trees to improve PH level of soils and protection from attacks by insects.

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These findings clearly show that majority of mango farmers are using new mango technologies to improve their mango production and cushion themselves from post-harvest losses. some of local technologies adopted were solar bags, sticky bands and other cultural practices. One of the cultural practices included deep ploughing of fruit orchard immediately after harvest. Further, 62% of the respondents control white mango scales by spraying using pesticides, use of agronomic practices (regular pruning) to remove infested parts of mango plants. The main pesticides used by the respondents to spray on mango trees were Folimat, Actara, Applaud chemicals and white oil.

Land ownership

The findings on landownership showed that, majority of respondents, 236 (62%), owned their land, while 144 (38%) leased their land. Mango is a perennial fruit, so farmers can plant it on their own property without incurring additional costs from leasing. Farmers who own their land tend to grow more mango trees than those who lease, owing to the constraints of leasing agreements. Mango farming relies heavily on land ownership, which has a significant impact on output and administration. It determines the size and potential growth of mango plantations, promoting long-term investments in critical infrastructure such as irrigation systems and soil management procedures required to maximize mango production. The land ownership was on the rise as observed from increased mango trees in farmers farms. The table showed farmers with over 20 trees which happened on their own lands.

Table 2: Number of Mango trees in the farms

Number of trees	Arrearage	%
a) 1 – 5 trees	≤1	39
b) 6-10 trees	≤2	31.9
c) 11-20 trees	≤3	11.7
d) 21-30 trees	≤4	8.2
e) 31-60 trees	≤5	2.9
f) 61-100 trees	≤6	2.8
g) 100-200 trees	≤7	2.3
h) >200 trees	≥8	1.2

Furthermore, land ownership determines crop rotation, intercropping strategies, and pest control measures, all of which have an impact on mango yield and sustainability. Secure land tenure also encourages the use of modern farming practices and innovations that improve mango quality and increase market competitiveness. Furthermore, land ownership provides farmers with collateral for loans and financial services, allowing them to invest in orchard maintenance, harvesting equipment, and market facilities. Finally, solid land ownership is critical to ensuring the resilience and profitability of mango cultivation, which contributes to long-term agricultural development and economic progress in mango-growing regions.

CONCLUSION

The study establishes that socio-economic and physical factors particularly climate change, drought, access to marketing, access to capital, government policy, pest and diseases and technological change exert significant influence on the performance and productivity of mango in Makueni county. Climate change and drought stood out uniquely at 92% to be the menace in Makueni county. The county experienced frequent drought, resurgence of pests and diseases due to an increase in temperature and reduced rainfall in the region. Marketing was minimal due to competing prices from other counties like Kilifi, low prices offered, low factory processing intake and high losses caused by poor storage facilities and transportation losses from the farms although market was both within and outside the County.

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The prices for mangoes were too low which reduced farmer's morale. Farmers had few cooperatives to sell mango as the stake to join cooperatives was high one was required to pay Ksh 2500-3500 to be member. In the cooperatives still mango was contractual. The sub-contractor bought the mangoes at Ksh 14 from farmers supplied to the contractor at Ksh 16 per Kg and the processing plant bought at Ksh 18 per kilogram. On good harvest findings, showed processing plant paid Ksh 21 from farmers per Kilogram. Access to Capital was a limiting factor, majority of farmers never qualified for bank loans and the little money received from the Savings and Credit Cooperatives never matched the entirely ever-increasing cost of inputs, costs of grafting of mangos, cultivars with high juice extraction Bx^0, transportation to markets, compromise of the quality of cultivars planted which resulted to low quality fruits thus low income.

Pests and diseases and changing technology posed great challenges and high costs to farmers. Majority of farmers deployed the indigenous practices to curb the effect of pests and diseases which led to immense droppings of both mango flowers and fruits leading to great losses. Despite continued pressure on mango performance and production farmers increased the arrearage under mango cultivation and each year there is new mango entrants thus Makueni remaining at float of increased mango production.

RECOMMENDATIONS

The Makueni county government should find measures of curbing the intensity of climate change to mango farmers, improve efficiency and operation of Kalamba mango processing plant to absorb much of mangos from its Makueni mango farmers. The government should deploy agricultural officers to guide mango farmers on possible solutions available to curb wastage of mango from pests and diseases. Further the study recommends a framework to be drawn between farmers, credit facilities and county government to provide short term loans, availability of the best mango varieties to cushion farmers from high cost of inputs and improve productivity.

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