Contributions of Mango and Local Agrarian Adaptation Strategies Deployed by Mango Farmers for the Sustainability of Livelihoods in Makueni County, Kenya

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ABSTRACT

Mango (Mangifera indica) is one of the most popular fruits worldwide, enjoyed by millions of people across many countries. It is a key tropical fruit produced in over 90 countries globally. Despite its wide cultivation, mango production per tree is often lower than its potential, with current yields averaging 180-200 fruits per tree, compared to the potential of 500 fruits per tree, signaling a significant gap in productivity. This study aimed to investigate the contribution of mango farming to local livelihoods and the strategies employed by farmers to enhance its performance and productivity in the drylands of Makueni County, Kenya.

A cross-sectional descriptive research design was utilized, supplemented by a case study of two farms located in the more remote areas of the county, to provide a deeper understanding of the situation. A total of 382 farmers were selected for the study using simple random sampling. In addition, purposive sampling was employed to select sub-county officers, ward officials, chiefs, sub-chiefs, village elders, and other key informants for interviews. Quantitative data was analyzed using descriptive statistics, including mean, percentages, modes, and regression analysis. Qualitative data were analyzed by identifying themes and patterns and validating the findings for their relevance.

The study revealed that mango farming plays a significant role in supporting livelihoods in Makueni County, driven by the adoption of various adaptation strategies by farmers. Mango farming provides crucial benefits such as income, food, shelter, and even traditional medicine. The findings also showed that mango production has been steadily increasing due to several factors, including the introduction of commercial mango varieties, the establishment of a Kalamba mango processing plant, and the application of modern farming technologies. The varieties that have gained popularity among farmers include Tommy Atkins, Kent, Van Dyke, Haden, and Apple, leading to a notable increase in production levels in the county. Between 2010 and 2022, mango production increased by 29.13% annually.

However, the study found that this increase in productivity was primarily driven by the expansion of mango acreage and improvements in agronomic practices. Therefore, it is recommended that coordinated efforts from multiple agencies be made to raise awareness and implement strategies to address challenges such as climate change, drought, and limited market access. Additionally, the adoption of appropriate post-harvest technologies, such as improved storage and transport systems, is critical to ensuring that production does not decline. Further research should explore the post-harvest behavior of different mango cultivars to enhance their shelf life and improve overall mango performance and productivity and value addition in mango products.

Keywords: Contributions of mango, Livelihoods, Local agrarian adaptation strategies, Makueni County

INTRODUCTION

Kenya's agro-ecological conditions are well suited to mango production. The country has a wide variety of

climatic and ecological conditions with altitudes ranging from sea level to over 5000 m in the highlands. The Mean annual rainfall ranges from 2000 mm in high potential areas, with most regions having suitable conditions for mango production (FAOSTAT,2015). Mangoes (*Mangifera indica*) do well in altitudes up to 1,500m above sea level with average temperatures ranging between 15^0 C and 30^0 C and annual rainfall of 850mm to 1,000 mm. Production overview indicates mangoes are produced in nearly all Kenya's regions. The main growing areas are Eastern and Coast regions which, combined, have 79% of national acreage (45,046 of 57,021 Ha) and volume (596,215 of 754,702 tonnes), followed by Central and Nyanza regions. Currently, Eastern region is the leading mango producer producing 204,179 tonnes, Coastal region 198,806 tonnes, Central region 43,359 tonnes, Nyanza region 37,612 tonnes, while another regions (ABD,2010)

Kenya has two mango seasons: a main season from October to March and a low season from May to July. 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)

Frequent droughts, climate change, pests and diseases, access to capital, government policies and fluctuating markets have occurred in Kenya in the last 30 years resulting to food insecurity, scarce pasture, and loss of livelihoods, human lives and of close attention is constraint to mango performance and productivity in Makueni County. According to Polynice, (2013) these factors globally have a crippling effect on mango performance and productivity, bringing in heavy economic losses thus low return to farmers affecting their livelihoods. Unless adequate steps are taken to minimize these problems, the performance and productivity of Mango may be severely affected in Makueni County, thus livelihoods lost to many local agrarian farmers of Makueni County.

Contempt to these limitations, mango growers must cultivate and earn profit. Additionally, financial constraints, lack of adequate infrastructure for marketing, frequent droughts, exacerbating climate change, pests and diseases, mango varieties, access to capital and government policies are of key concern to mango growing areas. These are to be analyzed at length and develop strategies that cushion farmers from impacts of these constraints.

It is instructive to note that a sizeable proportion of the rural labour force (over 51%) are engaged in small-scale agriculture and that women are the majority in the sector. A decline in agriculture has thus far-reaching implications in terms of employment and income inequality as well as food security for the country (Odusola, 2017).

To grow the mango sector further, the government has identified the sector among the economic pillars as a means of spurring growth in the Kenya Vision 2030 document, Agriculture Sector Development Strategy and the National Horticulture Policy. Therefore, products that have the potential for investment into value addition and hence create employment have been given attention and support. It is for this reason that the government is collaborating with development partners, private sector players and other stakeholders in realising this potential (Odusola, 2017).

In view of the above highlights, it is imperative to strengthen the adaptive capacity of the community to address these socio-economic and physical factors thus the need for an integrative approach that is cognizant to these factors in Makueni County. Enhancing performance and productivity in mango is important because of its effective contribution to poverty reduction, better food security and higher farm incomes. Against this background, this study seeks to quantify and evaluate the contributions of mango farming in Makueni County.

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 borders Kajiado, to the West, Taita Taveta to the South, Kitui to the East and Machakos County to the North
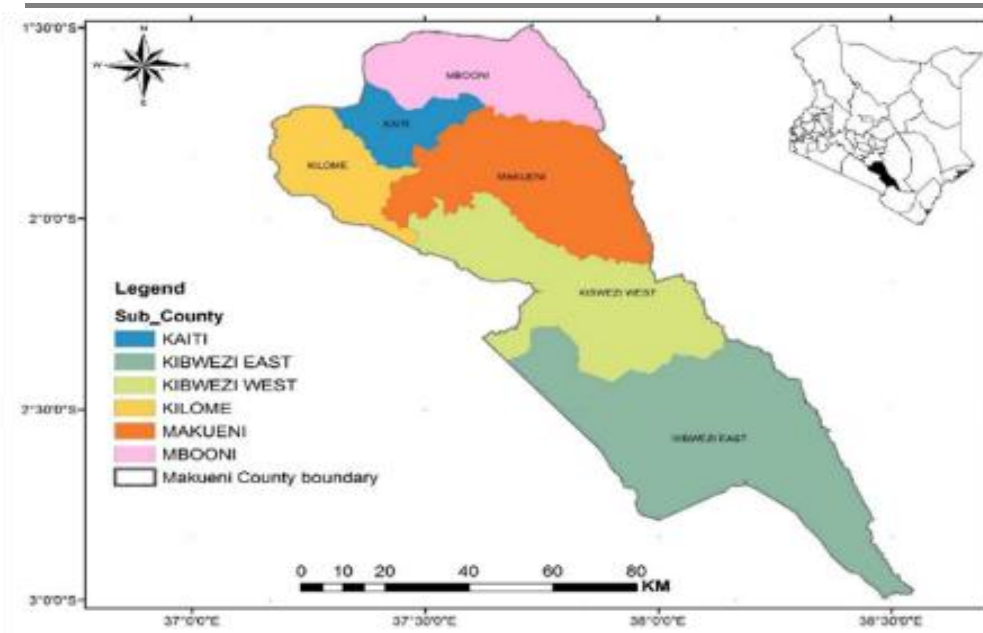
Fig. 1: Map of Makueni County - Kenya

Makueni 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 (Mumo, 2019). Long rains occur from March to May and short rains from November to December. According to Rajan (2012) short rains are more reliable and this is reliable and offer conducive conditions for mango growing. The economic activities undertaken in Makueni county entail: livestock rearing, fruit growing (mango, fixes, oranges, avocados, pawpaw) cereal growing, brink making, sisal farming. Mango farming is one of the major livelihoods of agrarian farmers of Makueni county thus paying attention to its to the performance and productivity.

Methodology

The study used cross-sectional research design where both quantitative and qualitative methodologies were deployed. A combination of techniques, both qualitative and quantitative, were used to obtain primary data. Data was obtained from 382 mango farmers using household questionnaires and 10 key informants using Key Informant Interviews schedules. Multistage cluster sampling technique was used to select respondents in the study area. In stage one, administrative constituencies were clustered. There are six constituencies in Makueni County with 30 wards and 16 mango cluster zones. In stage two, purposive sampling was used to select the study ward depending on cluster zone. Stage three was proportionate random sampling to select household respondents from all the six constituencies and 16 cluster zones. Mango divisions were identified and from the respective clusters proportionate mango farmers were identified with help of sub chiefs and ward administrators.

RESULTS AND DISCUSSIONS

The contribution of Mangifera indica to local livelihoods in Makueni county

The great diversity of mango fruit types permits its use for various purposes and markets. Mango processing entails the transformation of mango fruits into different semi-finished and ready-to use products. Such products include juices, jam, jelly, nectar, concentration and wine. Mangoes can also be used as a salad component, a salad appetizer, pickles, candied mango pulp, ice cream component, mango scoops or tidbit, mango shake and chutney.

Gathambiri, (2009) observed that most farmers sell their mangoes fresh once they are ready, some consume them at home (3.9%), make jam (1.3%), dried mango crisps (2.6%) and wine making (1.3%).

Contribution of mango to livelihoods

Uses of mango	Percent %
Food	40.4
Source of income	58.2
Shelter	1.2
Traditional medicine	0.2
Total	**100.0**

Source field data,2022

Respondents were probed to indicate the contribution of mango to their livelihoods. The findings show that 221(58.2%) sold mango for income while 154(40.4%) used this as food ,5(1.2%) of trees provided shelter from scorching sun while 0.2% of farmers indicated they use the infused leaves with barks to disinfest wounds and for malaria treatment. Findings showed mango juice is the most common product. The income raised from the sale of mangoes to produce concentrate. These findings coincided with study by Musyimi,2016 who observed several mango processors in Kenya.

Processors include Kevian Kenya Ltd, located in Thika, which sells juice under the trade name of "Pick and Peel" and Sunny Processors (Ruiru) which produce, and export mainly pulp (Sunny Processors, 2010) and others such as Milly (Mombasa) and True foods (Nairobi). Some processors, e.g. Del Monte (Thika) import the concentrate from outside Kenya and then convert into juice for the Kenyan market. The juices are packaged in Tetra Pak carton packages and plastic bottles and sold locally (Musyimi, 2016).

Farmers mango earnings

Earnings in Ksh. per month per season	Percent %
a) Less than 30000 shillings	5.3
b) 30000-50000 shillings	21.3
c) 50000-70000 shillings	36.6
d) 80000-100000 shillings	26.1
e) Above 100000 shillings	10.8
Total	**100.0**

Source. field data 2022

Qualitative data, from agricultural officers indicated reduced production per farmer also led to less income generated by the farmers per season. It was noted that revenue generated by farmers has fluctuated for the last 30 years, an issue coupled by an increase in farm input. Most 140(36.8%) of the farmers were earning between 30,000 and 50,000 shillings from the sale of mangoes per season. The money was used for payment of school fees by parents and buying food. Food was highly cited as the region has experienced drought for the last three years when rain has failed.

Plate 1: Mango processing plant

The Makueni mango processing plant provides also employment for over 4000 Casual workers during pick of mango harvesting. The mango processing plant also has provided permanent employment for over 50 people as chemical engineers, mechanical engineers, machine operators, marketers, watchmen and administrators. This has improved the living standard of the Makueni people. The mango processing plant was found to offer educational expertise to farmers such grafting of mangos and advise on best mango cultivars.

Plate 2: Workers on mango processing plant

Plate 3: Mango processing plant drivers

The interview with the Agriculture Director revealed that the Makueni County government receives tax revenue from the processing of mangoes, generated through the sales of mango products both within and outside the county boundaries

The local agrarian adaptation strategies to Mangifera indica performance and productivity in Makueni County

The findings from the field reveal that a few adaptation strategies were deployed by farmers despite the severe constraints caused by climate variations, drought, market, capital accesses and diseases, technology and policy related issues.

Measures put in place to cope with the changes

Adaptation	%
Irrigation	44.6
Pesticides	55.4
Total	**100.0**

Source field data, 2022

As a result of such changes, 211(55.4%) of the respondents noted that they were using pesticides to mitigate the problem of mango fruits droppings. Other 169 (44.6%) were using irrigation in their mango farms. However, it was also observed that most 211(55.4%) of the farmers had not been exposed to visits to benchmarks on mango farming. The plate below showed irrigated mango trees in some farms while other

farmers dug furrows to hold water during the rainy season. The retention of water in the farrows boosted the trees' water retention level thus offering survival during extreme dry seasons.

Plate 4: Irrigation on mango tree;

Plate 5: furrows for holding water in rainy season

Plate 6: Extreme pruning of mango trees

Observations made during the study unearthed extreme pruning of mango trees by some farmers to limit canopy growth, a practice which reduced evaporation. This pruning technique also minimized the availability of hiding spots and habitats for insects and diseases. By using this method, farmers aimed to reduce evaporation from the mango trees. Additionally, the increased light penetration to the "heart" of the grafted mango trees promoted flowering and vigorous flower growth, ultimately leading to improved performance

Adaptation toward climatic change/drought?

Strategy	%
Cultivating different mango varieties	13.2
Changing planting dates (*immediately after rain onset*)	49.5
None (*farmers lack knowledge on what to do*)	7.6
Increasing cultivating land (*increasing mango trees*)	10.8

Switching from crops to livestock rearing	8.9
Switching from livestock to crop	7.6
Searching for off-farm jobs	2.4
Total	**100.0**

Source field data ,2022

The farmers were asked to tick most adaptation practices the frequently performed in their farms, the findings indicate that the most respondents 188(49.5%) had adopted changing planting dates, 50(13.2%) adopted Cultivating different mango varieties ranging from *Tommy Atkins, Kent, Van Dyke, Haden, and Apple*, 41(10.8%) adopted increasing cultivating land under mango, 34(8.9%) switched to livestock, 29(7.6%) switched to crop farming, while a few 9(2.4%) switched from farming to searching for off- farm jobs.

Organized exposure visit

Exposure visits	Percent %
Agricultural officers/county officers/personal initiative	44.2
None (no officer visiting)	55.8
Total	100.0

Farmers who had been exposed to regular visits were about 171(45%), but the majority 212(55.8%) had not been involved in any farm exposure visits. These respondents indicated the visits were by agricultural officers/ county officers and while others had taken a personal initiative which was expensive and minimal.

Adaptation measures

Strategies	Percent %
Cultural practices	40.0
Solar bags	45.0
Sticky Bands	15.0
TOTAL	100.0

Source: field data 2022

The findings show that majority of respondents, (45%), use solar bags to reduce the effect of pests in the farms. Cultural practices included applying ash on leaves and tree trucks to keep insects and ants away from attacking the mango. Tree branches from pruned trees were burned around the tree trunks to chase away insects affecting the tree and the scent simulated flowering.

Plate: 7 Solar bags for fruit fly trappings in Thomson farm Kalamba

Adaptations measures toward corresponding factors

Factor	Percent %
Pests and diseases	13.4
Markets	9.5
Drought and climate	10.5
Technological change	42.6
Capital access	23.9
Total	**100**

Source field data ,2022

Adaptation strategies were explored with mango farmers, and the findings revealed that the primary focus was on technological adaptation, with 162 farmers (42.6%) prioritizing this approach. This was followed by government policy (91 farmers, 23.9%), pest and disease management (51 farmers, 13.4%), while the least attention was given to market access, despite the presence of a mango processing plant in Makueni. The factory sourced mangoes from across the country based on maturity, open tendering, and market prices, which limited the market opportunities for Makueni farmers. All four factors scored significant attention, highlighting the need for improved adaptation strategies in mango farming. These findings aligned with observations that Makueni farmers were significantly impacted by these issues, underscoring the need for greater focus on enhancing their livelihoods.

Where are the sources of markets for Mango on your farm?

Sources of markets (*within and outside the county*)	%
Internal (in the county)	34.5
External (other counties)	65.5
Total	**100.0**

Source field data ,2022

A majority of 249 farmers (65.5%) relied on external sources for selling their mango produce. While mango farmers sold to buyers outside the county to avoid waste, the prices they received were extremely low; Ksh 14 per Kilogram. Brokers set the prices, often offering very little in return. The quality of the fruit and transportation methods also influenced the prices, as brokers preferred mangoes free from scratches or spots, which were seen as signs of potential rotting. This led to even lower prices for mangoes.

Cooperatives and CBOs in mango production

Farmers in cooperatives	Percent %
Yes	43.7
No	56.3
Total	100.0

Source field data, 2022

A total of 163 respondents (43.7%) indicated that cooperatives had an influence on mango production, and they paid the entry cost to tap the benefits. Farmers who joined groups demonstrated greater bargaining power compared to individual farmers. However, many farmers (56.3%) expressed concerns about the high cost of joining the Community-Based Organizations (CBOs), which required over Ksh 2,500 (19 dollars), a fee they

found burdensome. Despite this, they felt that joining the cooperatives was the only viable option for selling their mangoes and earning a fair income from their farming efforts.

Adaptation to Late flowering

Plate 8a: Late flowering

Plate 8b: Early flowering

Farmers reported that unexpected rainfall during the mango flowering season caused several issues: damaged flowers, loss of pollen grains due to rainwater, reduced pollination as pollinating insects became less active, fungal growth and leafhopper infestations on flowers and fruits due to the humid conditions, and difficulties during harvesting as many flowers and fruits fell due to dew and fog. To address these challenges, farmers adopted strategies such as burning branches beneath the tree canopy to stimulate the tree bark. Other farmers pruned the trees to allow more light to reach the grafting areas, which they believed helped stimulate flowering.

CONCLUSION

The empirical results showed that farmers in Makueni County consistently expanded the area dedicated to mango cultivation, increasing both the number of mango trees and the adoption of improved mango cultivars each year. Despite facing significant challenges such as climate change, drought, limited market access, lack of capital, government policies, pests, diseases, and technological changes, mango production has continued to rise since 1991. This positive trend contradicts global patterns of declining mango production and can be attributed to the strategies implemented by local farmers.

The study also found that mango farmers in Makueni have developed local strategies to mitigate the impact of these constraints. As a result, mango performance and production have remained on an upward trajectory despite the numerous challenges faced.

Furthermore, the study concluded that mango farming plays a crucial role in the livelihoods of Makueni residents, contributing to income generation, food security, and other benefits. A significant portion of farmers own mango trees, with many shifting from livestock farming to fruit farming. This transition underscores the importance of mango cultivation to the county, though it is closely rivaled by orange farming. Overall, the

findings indicate that farmers have made notable progress in adapting to challenges, building resilience, and applying current orchard practices to enhance mango farming despite the constraints they face.

RECCOMMENDATIONS

The County Government of Makueni and collaborating agencies should integrate mango farmers into comprehensive capacity-building initiatives, incorporating social networking platforms to promote the adoption of technology aimed at improving mango cultivation. These initiatives should prioritize the cultivation of robust mango varieties that enhance quality, resist pests and diseases, and strengthen marketing efforts. In cases where there is a scarcity of extension officers, virtual platforms such as online meetings, Facebook pages, and WhatsApp can effectively address farmer concerns and provide necessary support.

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