Mechanization Levels And Options For Mango Value Chain In Makueni County, Kenya

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Abstract- Low agricultural productivity in Kenya has been associated with low levels of mechanization among other factors. Several efforts have been made by the government and non-governmental organizations to promote the use of agricultural machines in various parts of Kenya. Mechanization level and productivity in the mango value chain remains low. The goal of this study was to assess the level of agricultural mechanization in mango value chain in Kenya and make appropriate recommendations. Sampling procedure was adopted in selecting respondents. The first cluster of sampling was random selection of the sub-counties and the second was the sub-locations and lastly the farmers. Data was collected at three levels, secondary sources through desk reviews, key informants' interviews using checklists and primary data collection from farmers using semi-structured questionnaires. Farmers were categorized into three levels, small, medium and large scale on the basis of acreage under mango production. Results obtained revealed low level of mechanization across the three categories of farmers during ploughing with 58% of farmers using oxen during ploughing. The other farm operations, however, were largely manually. Over 50% of medium and small-scale prepared holes manually, either using hoe then plant. There was no use of chemicals in weeding for small and medium scale farmers although for large scale farmers 7.6% used chemical for weeding. The dominant type of pruning according to the respondents covered was manual. All the medium and large-scale farmers pruned their mangoes manually. The popular method of harvesting mangoes was manual by use of hands, climbing the tree or using hooked long pegs or wires.

Index Terms- Farm category, Machines, Mango and Mechanization

I. Introduction

In Kenya land preparation and weeding are major farm activities that require mechanization but these activities are largely depended on manual labour (Oluoch-Kosura, 1983). For example, weeding in Western Kenya is primarily done by manual labour (Okello and Wasike, 2000), despite there being technologies for weeding in the region. Tractors are needed for deep land preparation, cultivating of heavy soils and shelling of maize (Bymolt and Zaal, 2015). Tractor owners are renting out their tractors at a higher cost. This is because of soil factors (clayey soils), high cost of maintenance and lack of skilled manpower to repair the machines (Bymolt and Zaal, 2015). Many farmers lack necessary implements and /or machines to carry out these tasks (Okello and Wasike, 2000).

In a study carried out by Sims and Kienzle (2007), it revealed that there is increased demand for agricultural mechanization by both large scale and small-scale farmers. Hiring of equipment was preferred by most of the respondents so long as the prices were competitive (Sims and Kienzle, 2007). It was also revealed that many manufacturers preferred manufacturing of equipment with high turnover such as the hammer mill instead of tillage implements (Sims and Kienzle, 2015).

Several key issues were identified that are ailing agricultural mechanization in Kenya, including; lack of adequate training for *Jua Kali* artisans, lack of coordination between principal stakeholders in the mechanization input supply chain, few manufacturers of agricultural equipment and manufacture of equipment for small scale farmers was left to artisans (Sims and Kienzle, 2007).

In 2003, mango production was estimated at more than 183,000 tonnes, with Eastern Province accounting for 54%, Coast Province 22% and Nyanza Province for 8% of the total national mango production (Gor et al., 2012). Over the past decade, mango production in Kenya has grown rapidly. Production volume between 2005 and 2012 tripled from 254,113 tonnes to 754,102 tonnes (FSD-K, 2015). Additionally, the growth in the sub-sector has been stimulated

by the increasing demand for mangoes in domestic, regional and export markets, and the fruit is considered a major income earner for many smallholder-farming households.

Kenya has two distinct major harvest seasons for mangoes, the first period starting from May to July and the second period from October to March. Counties that supply mangoes during august-September short season are Makueni, Tana River, Garissa, Baringo, West Pokot, and Turkana. In April, mango supply comes from Kwale, Kilifi, Taita and Tana River counties. The market for fresh mangoes currently absorbs an estimated 47% of total production, exports 2%, processing 8%, home consumption and give away 18%, with losses estimated at 25% (FSD-K, 2015).

The sector is both technologically and organizationally complex mainly due to dynamic nature of farming characterized by low productivity and low use of farm inputs including agricultural mechanization, poor infrastructure, lack of rural finance and poorly developed markets. Other constraints affecting growth of the mango sub-sector include low soil fertility, unreliable rainfall, pest infestation, diseases, and poor

Infrastructure, marketing and policy bottlenecks and low profitability attributed to a combination of germination problems in the nursery, pests and diseases during the growing period, harvesting low yields and poor marketing strategies. The goal of this research was to assess the mechanization levels in mango value chain in Makueni County. The specific objective of this objective was to establish the levels of agricultural mechanization among mango farmers across different farm levels and recommend interventions for promoting use of machinery within the mango value chain.

II. Study Methodology

2.1 Study Site

This study was conducted in kibwezi west subcounty in Makueni County. Makueni county lies in the Kenya's lower Eastern region. Its capital and largest town is Wote. The county has a population of 987,653 (2019 census). The county lies between Latitude 1o 35´ and 32 00´ South and Longitude 37o10´ and 38o 30´ east. It borders Machakos to the North, Kitui to the East, Taita Taveta to the South and Kajiado to the West and covers an area of 8,008.9 km^2. The county experience semi-arid climatic conditions with an average temperature range between 15C – 26C and Annual rainfall ranges between 250mm to 400mm per annum on the lower regions of the county and the higher region receives rainfall ranging from 800mm to 900mm.and is currently the leading mango-producing region in the country. The region contributes about 37% of national mango production and about 62,150 households rely on the sector for income (FSD-Kenya, 2015; Olumeh, 2014). The region also dominates the supply of mangoes for export. In the Eastern region, mango-growing families receive 22% of household income from mango sales. The study site is presented in Figure 1.

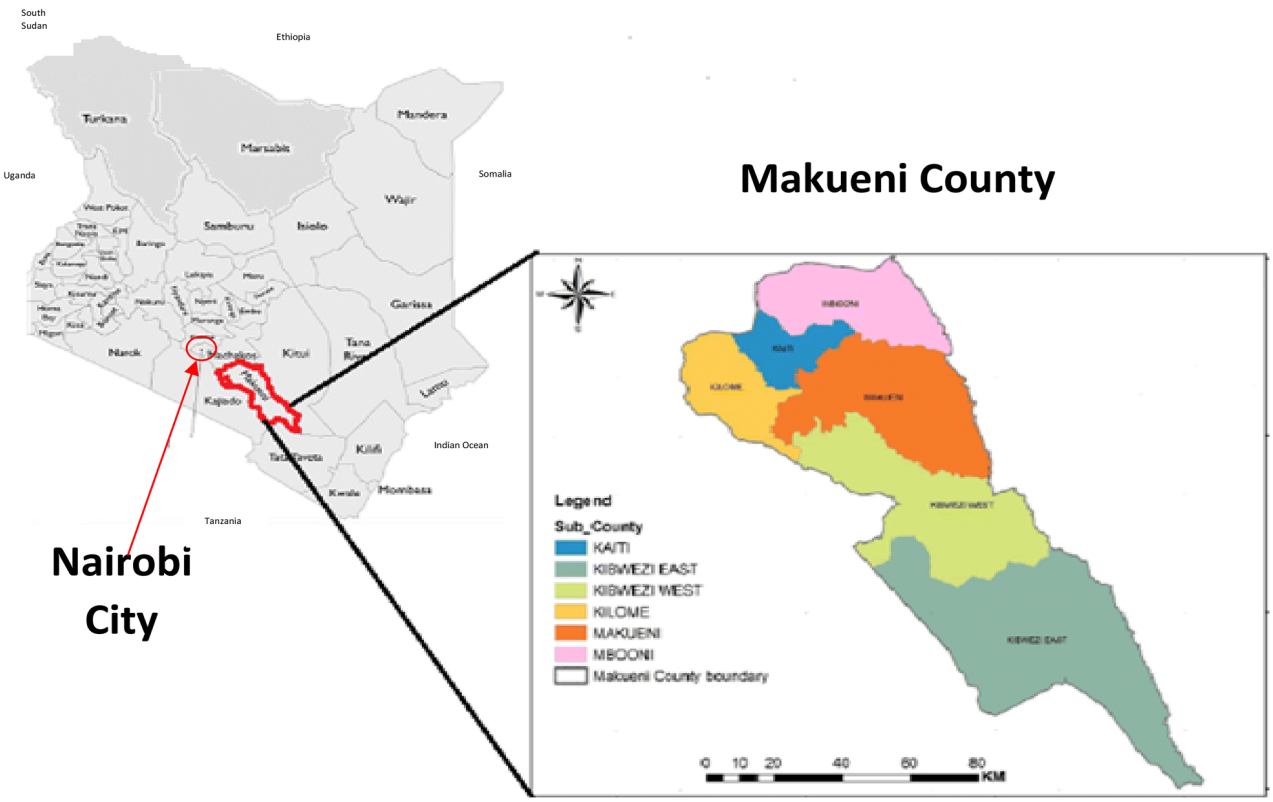

Figure 1: Map of Makueni County

2.1 Sampling design

The survey was conducted using multistage sampling design. The first stage of sampling was to choose the value chains based on their incomes generated to the country. In the second stage the county was selected based on the importance of the value chain in terms of their production. The third stage was the selection of the sub-county and wards. The final stage of sampling was choosing the respondents based on the farmers' list (sampling frame) provided by the County Director of Agriculture staff and farmer organizations. The apportioning of sample size was then calculated proportionally for the different farm categories, half of the respondents were small-scale farmers as displayed in Figure 1. They owned less than 5 acres of land On the other hand, 30% and 20% were medium and large-scale farmers, respectively. The respondents were drawn randomly from the lists of farmers as provided. A total of 60 respondents were interviewed based on enterprise size categories of small, medium and large scale.

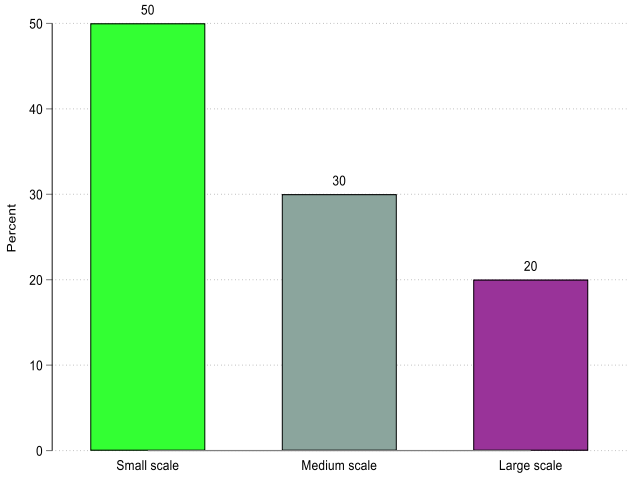

Figure 2: Distribution of respondents by farm scales in Makueni County

2.2 Data collection tools and sampling

The main tool used for data collection was a semi-structured questionnaire and the use of key informant interviews (KIIs). The survey was undertaken in three phases. The first phase involved collecting secondary information and desktop reviews, where data

collection from key informants included taking notes, use of checklists and discussions. The survey team visited key stakeholders and held discussions on key variables including agricultural mechanization, production practices and policy issues as well as constraints and proposed interventions. The stakeholders included development partners, relevant research institutions, universities, agro-dealers, headquarters and county Ministry of agriculture.

The second phase of the survey involved recruitment and training of enumerator's as well as pre-testing of the questionnaire for the different value chains. The top four candidates were selected and trained on the survey methodologies and tools. The questionnaires were pretested and areas that required special attention refined.

The third phase of the survey involved actual implementation of the questionnaire in the county. The questionnaires were administered to the respondents by the trained enumerators particularly on their farms where coordinates and elevations were determined using global positioning system (GPS) equipment. The completed questionnaires were inspected and corrected by the respective coordinators.

2.3 Data Analysis

Data was analyzed using both descriptive and inferential statistics using Stata. Summaries of analyzed data are presented in tables and bar graphs. Frequencies and percentage tables were used to present results from the analyzed data to undertake comparisons of the variables across the different farm sizes for the various mango farm operations.

III. Results and Discussion

3.1 Levels of Agricultural Mechanization

This section analyses and discusses the mechanization levels, costs, types of labour and equipment used and makes inferences from the survey data.

3.1 Land preparation

Mango is a perennial fruit tree, where by land preparation is done once and it involves bush clearing, cultivation and digging of holes and this is either done manually, use of oxen or tractor. Majority of the respondents 48% used oxen in small scale farmers while 32% in medium scale farmers, costing averagely KES 2800. The use of tractor for land preparation is limited (58%) in large scale farmers and Manual labour 35% in large scale farmers. The cost for land preparation per acre by either oxen tractor or manual in both small, medium and large scale had a slight difference hence the p value which is used to measure the significance for the mean cost was not statistically significance (Table 1). This may be attributed to the fact that majority of the households in lower Eastern region keep oxen for land preparation and also tractors are few and used majorly by large scale farmers, and when available they are expensive to hire. The gender involved in land preparation were mainly adult male and female (42.9%) as depicted in (Ffigure 3) and this could because of other members of the household either being in school and also labour migration to urban centres. The source of labour was mainly casual labour.

Table 1: Frequencies, percentages, and costs of land preparation by farm scale

	Oxen Option				Tractor Option				Manual Option		
	Freq.	Mean Cost per acre (Ksh)	P-value for Mean costs		Freq.	Mean cost for per acre(ksh)	p-value for mean cost		Freq.	Mean cost per acre (Ksh)	p-value for mean cost
Small scale	19	2308	0.141		3	3167	0.884		7	1686	0.376
	48%	(1506)			25%	(1607)			41%	(1675)	
Medium scale	13	2650			2	2650			4	2725	
	32%	(2180)			17%	(919)			24%	(3545)	
Large scale	8	4250			7	4571			6	3917	
	20%	(3713)			58%	(6822)			35%	(3247)	
Pooled	40	2808			12	3900			17	2718	
	58%	(2354)			17%	(5162)			25%	(2776)	

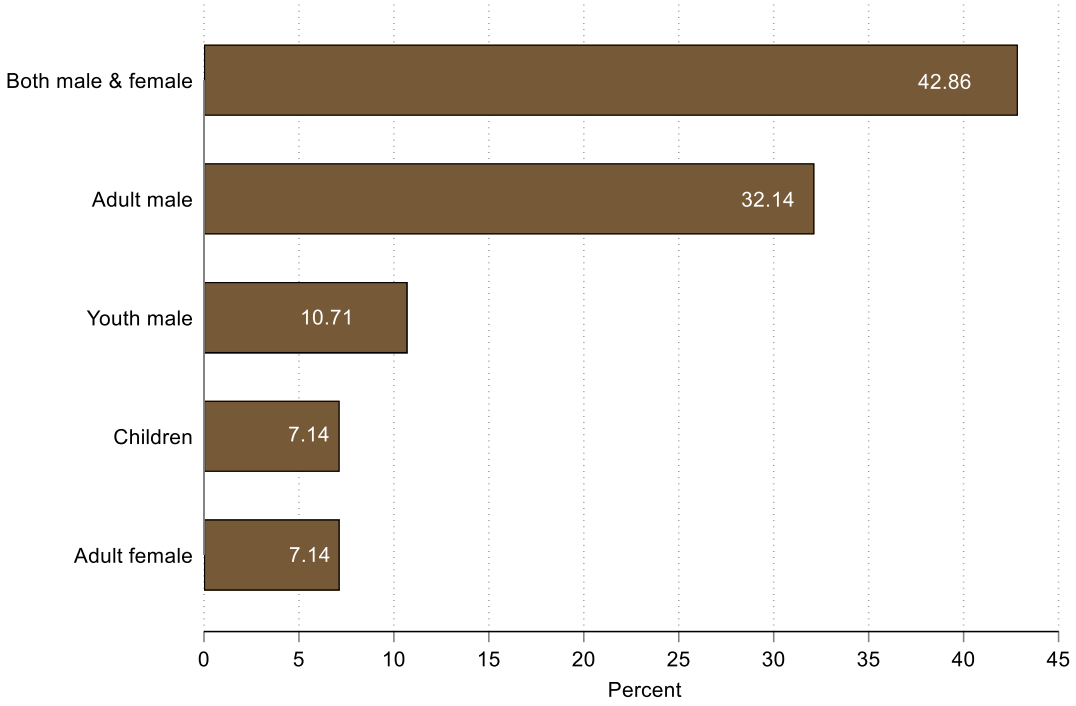

Figure 3: Percentage of gender involved in land preparation.

3.2. Planting of Mango seedlings

After bush clearing and cultivation, the next activity is to dig holes for planting seedlings. Various tools were used in combination and they include the hoe, fork jembe mattock and shovel. The hoe is usually used to remove the top soils while the mattock and fork jembe are used on the hard pans as the holes become deeper while the shovel is used to remove the soils. Overall, the hoe was the most commonly used implement with over 50% of the respondents using it (Table 2). The activity is mostly done manually and the source of labour was casual labour while the gender involved was mainly the adult males and male youth and this is because the work is laborious and thus difficult for female and children.

While land preparation is mechanized through the use of oxen and mould board ploughs and tractors, digging of holes is usually manual and labour intensive and therefore it is an area that may require intervention in terms of mechanization. The variation in the tools used across the farm sizes was minimal.

Table 2: Percent responses on the type of equipment used in planting mango seedlings.

Equipment type	Small scale (%)	Medium scale (%)	Large scale (%)	Pooled (%)
Hoe	58.1	39.1	50	50
Fork jembe and mattock	0.0	4.3	0.0	1.7
Hoe and Shovel	12.9	13	0.0	11.7
Mattock	0.0	8.7	0.0	3.3
Hoe and Mattock	3.2	8.7		5
Hoe, Shovel and Mattock	3.2	0.0	0.0	1.6
Fork jembe and Shovel	0.0	0.0	16.7	1.7
Hoe, fork, shovel & mattock	22.6	26.1	33.3	25
Sample size (N)	30	18	12	60

3.3. Weeding

Due to the spacing of mangoes, other crops are usually planted between the fruit trees and therefore weeding is done regularly. Results reveal that weeding was done manually and there was limited use of chemicals (7.6%) for weeding (Ffigure 4). Overall, more than 90% of the respondents indicated that they don't use chemicals for weeding. Disaggregated by category of farmers all small and

medium scale farmers did not use chemicals except for 7.6% of large-scale farmers used chemicals and interculturalists. All the farmers who reported using chemicals used a knapsack sprayer.

Hoe and machete were used for manual weeding either singly or in combination. Source of labour for weeding was mainly casual and family labour (Figure 5), while the gender involved in weeding were male adults and a combination of adult male and female.

The fact that both small and medium scale farmers used mainly manual labour with only 85% of the large scale using manual labour this portends an immense opportunity in mechanizing of weed management and therefore improve efficiency, productivity and income in the mango value chain.

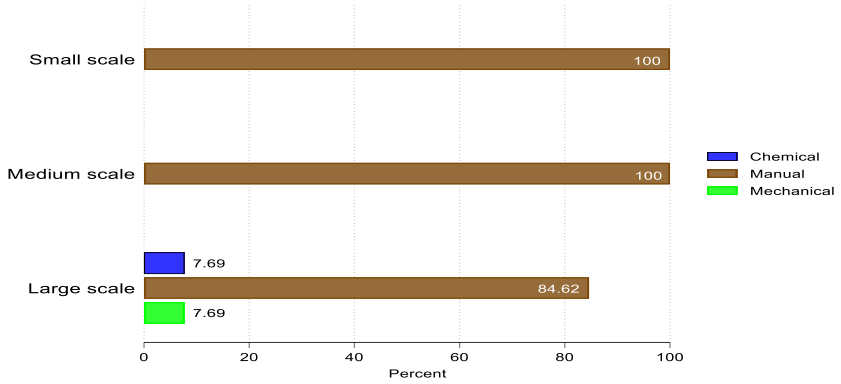

Figure 4: Percentage responses on the types of weeding by farm size

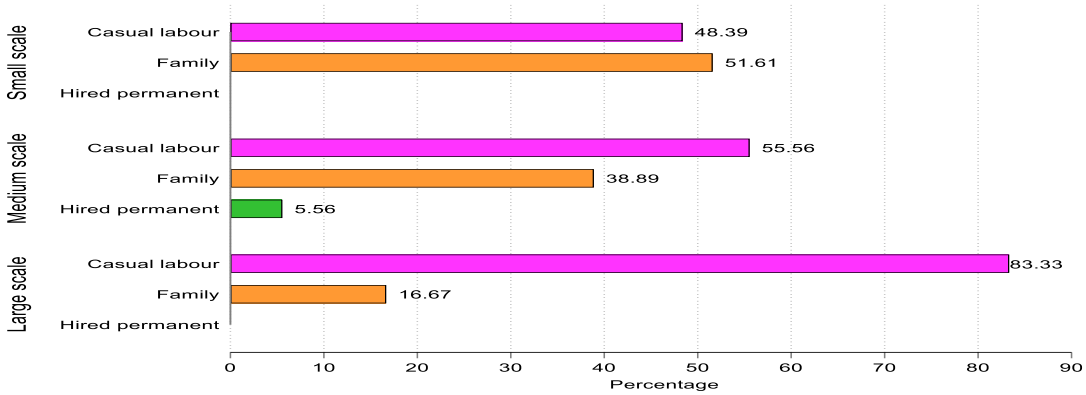

Figure 5: Percentage Type of labor used in weeding by farm sizes

3.4. Top-dressing, manure application and pest control

Farmers top-dressed their mango fruit trees and the method used was manual. Manure option is a commonly used in Makueni county to improve soil fertility. In this study over 80% of respondents applied manure to their mango seedlings and fruit trees. It is applied both during planting and also when the fruit trees are established. There were no notable differences between the different farm categories (Figure 6). The method of application was not mechanized with all the small, medium and large-scale farmers applying manually. Therefore, this is an area that requires development and promotion mechanization in the mango value chain.

Farmers used chemicals to control pests with about 98% of all the respondents interviewed reporting its use. Disaggregated by farm category, all the small, medium and large-scale farmers used chemicals. The method of application of chemicals done using knapsack by all small, medium and large-scale farmers

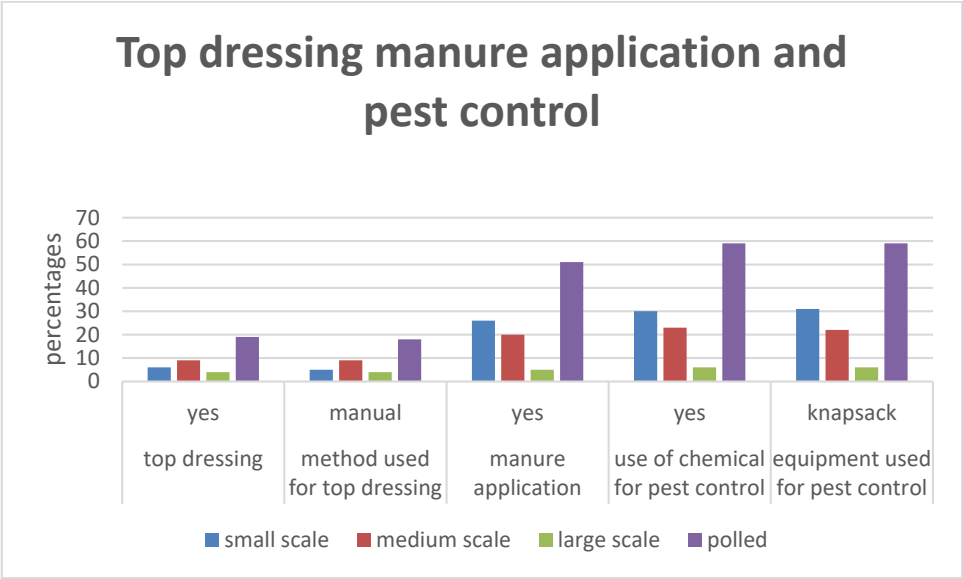

Figure 6: Percentage responses on top dressing, manure application and pest control by with farm size

3.5. Pruning, harvestingg Transportation

To improve productivity of mangoes regular pruning is recommended to reduce the number of branches. There are two types of pruning, either manually or using hand held machines. The dominant type of pruning according to the respondents covered was manual. All the medium and large-scale farmers pruned their mangoes manually (Figure 7). Clearly therefore there is need for promotion of mechanized pruning machines which are available in the market. The type of pruning equipment used for pruning was reported as the pruning saw. The other equipment used by a few farmers was the machetes and secateurs. Like the other activities source of labour used for pruning was mainly casual and family labour.

The popular method of harvesting mangoes was manual by use of hands, climbing the tree or using hooked long pegs or wires. Most of the mangoes in Makueni is sold on-farm and the task of harvesting is left to the buyer. This could be attributed to the fact that mangoes deteriorate very fast after harvesting and therefore farmers cannot harvest and store as they wait to sell. Labour for harvesting was mainly by casuals hired by the buyers.

Three types of transportation were reported as the wheelbarrow, motor vehicle or humans. Humans transport mangoes either by putting it on their backs or heads.

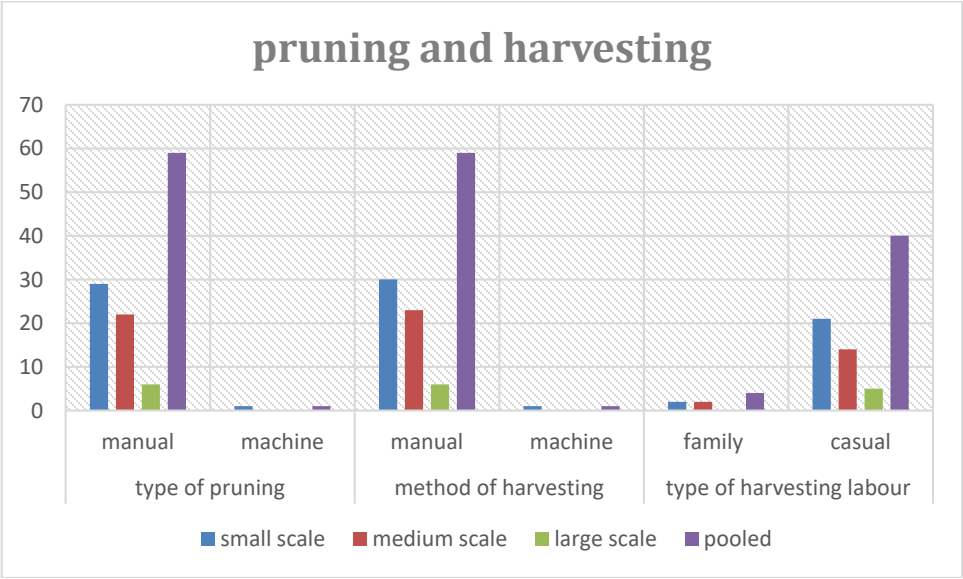

Figure 7: Percentage responses by types of pruning and harvesting by farm size

Figure 8 pruning of mango (source: The hansindia.com)

3.2 Agricultural Mechanization Options and promotion strategies

This section reviews the possible mechanization options available, promotion and use of machinery and thereby improve adoption, efficiency, productivity and income along the mango value chain in Kenya and other countries.

3.2.1 Mechanization options

Mechanization interventions in mango crop for production, post -harvest operations and value addition are relatively low and need to be focused on so as to improve crop productivity and profitability. Precision in operations at different stages of growth will address the challenge of enhancing productivity and profitability of mango crop. A review of mechanization technologies developed in other countries for mechanization of mango crop need to be introduced and farmers trained for adoption. From Table 3 it is clear that the mechanization options across the mango value chain that can either be fabricated and developed or acquired for training and use to mango farmers to improve adoption.

There are different machines which are used in all operation of mango value chain (Table 3). In land preparation small scale farmers can use walking tractor but large- scale farmers have already adopted the tractor drawn. In planting the labour used was manual labour hence there is need of mechanizing by introducing the tractor drawn planter. fertilizer application is supposed to use fertilizer applicator so as to reduce the time and wastage spend during manual application. Knapsack for spraying pest though there is a better option of using air carrier sprayer which can be used by large scale and medium scale farmers. Most of farmers use jenbe or chemical for weed control hence introduction of a mechanical weeder to farmers will be a better option.in pruning farmers are encouraged to use pruning machine instead of panga. Harvesting of mango is done using potable mango harvester which will reduce losses will hind picking. In value addition there is mango peeler and juice maker which will help both small, medium and large-scale farmers to reduce losses during bumper harvest. Transportation of mango is done using trucks which are installed with crates for safety since farmers use bicycle to transport to the market but by the time, they reach the market the mangoes are spoilt.

Table 3: Mango Mechanization options

Type of Operation	Current Method	Mechanization Options	Remarks/Picture for Machinery
Land Preparation	Tractor plough/ oxen drawn plough / manual	Tractor drawn plough	Most of the farmers are already using tractors but training on how and when to prepare land for mango planting is very important.

Planting	the hoe, fork jembe mattock and shovel	Use of a tractor drawn planter	
Fertilizer Application	Manual by use of hand	Fertilizer applicator	
Weed Management	Use of chemicals/ use of jembe	Mechanical weeder / tractor drawn	

Pest management	Use of knapsack sprayers	Air-carrier sprayers	
Pruning	Manually by use of pruning saw, machetes and secateurs	Using a pruning machine	
Harvesting/Picking	Hand picking	Portable mango harvesters	 

Peeling	Use of knives/	Use of mango peelers	
Processing	Juice making machines by use of blenders and fruit pulpier		
Transportation	Use of motor cycles/bicycles/ wheel barrows	Use of trucks with installed mango crates for safety	 

3.2.2 Mechanization Promotion strategies

Capital is an important factor of production in agriculture and more so in mango production. Mangoes being a perennial crop require initial heavy investment to cover land preparation and acquisition of inputs both for planting and maintenance of the crop till the first harvest which could be 3-4 years after planting. Sources of funds include farmers own savings and borrowing. Amongst rural farmers savings are minimal and thus the only viable option to get funds is through borrowing. Increased agricultural production and improved rural livelihoods cannot be achieved without the adoption and use of increased levels of farm power and mechanization.

Setting up small-scale farmers credit scheme, especially for purchase of machines could be an important step towards accelerating mechanization adoption. Because the small-scale farmers may not be able to acquire credit from the mainstream financial sector due to the risky nature of their business, the government could step in either as a guarantor or as a direct provider of the funds through, say microfinance institutions. An alternative approach could be to mobilize the small-scale farmers to form organizations through which to

pool resources and obtain additional funding from either the government or financial institutions. Whichever approach is chosen, the funds should be low-interest and easily accessible.

IV. Conclusion and recommendation

Mango production can be substantially increased through the use of mechanical technologies which are both labour saving and directly increase yields and production. Inputs of hard labour by farmers and their families can be substantially reduced if they have access to a carefully selected use of tools, machines, and equipment. The labour released can be used for other productive activities. The use of improved mechanical technologies can also have a direct impact on yields and area under production.

The findings from this study are crucial in generating information that will help in understanding of the existing agricultural mechanization practices. This will also help in guiding the research agenda for agricultural mechanization, promotion of existing technologies and make technical and policy recommendations not only in Kenya but the rest of Africa. The implementation of recommended technical and policy interventions will lead to the realization of measurable qualitative and quantitative outcomes through the improvement of productivity on mango value chain ensuring improved farm production, incomes, and food and nutrition security

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