Volume 1 No: 2 (2017)

Status, Challenges, and Prospects of Agricultural Mechanisation in Kenya: The Case of Rice and Banana Value Chains

Makini, F.W; Kamau, G.M; Mose, L.O.; Ongala, J; Salasya, B; Mulinge, W.W and Makelo, M.

October 2017

Citation
Makini, F.W; Kamau, G.M; Mose, L.O.; Ongala, J; Salasya, B; Mulinge, W.W and Makelo, M, (2017). Status, Challenges, and Prospects of Agricultural Mechanisation in Kenya: The case of Rice and Banana value chains. FARA Research Results Vol 1(2) PP 24

Corresponding Author
Dr Lawrence O. MOSE (Lawrence.Mose@kalro.org)

Forum for Agricultural Research in Africa (FARA)
12 Anmeda Street, Roman Ridge PMB CT 173, Accra, Ghana Tel: +233 302 772823 / 302 779421
Fax: +233 302 773676 Email: info@faraafrica.org Website: www.faraafrica.org

ISSN: 2550-3359

About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.
FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).
FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its **mission is the** "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its **Value Proposition is the** "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision.

About FARA Research Result (FRR)

FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access

Disclaimer

"The opinions expressed in this publication are those of the authors. They do not purport to reflect the opinions or views of FARA or its members. The designations employed in this publication and the presentation of material therein do not imply the expression of any opinion whatsoever on the part of FARA concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its frontiers".

Acknowledgements

This work was carried out within the Program of Accompanying Research for Agricultural Innovation (PARI), a project that is coordinated at the global level by the Center for Development Studies (ZEF), University of Bonn in Germany. The PARI project is also coordinated in Africa by the Forum for Agricultural Research in Africa (FARA). The funding for this work was provided by the German Federal Ministry of Economic Cooperation and Development (BMZ), whom the authors are grateful to.

The authors wish to acknowledge the contributions of the different individuals in ZEF and FARA for the reviews of the proposals and the final outputs of the research endeavours. The contributions of Dr. Fatunbi Oluwole and his team in FARA, as well as Dr. Heike Baumüller and her team at ZEF are well acknowledged.

The authors further wish to acknowledge the contributions of all the rice and banana value chain actors in Kisumu and Kirinyaga Counties, who enabled us to gather quality data for this report. We would also like to thank all the enumerators who collected data and information from farmers and other value chain actors. In addition, we acknowledge rice and banana farmers, and processors in the two project Counties who graciously provided the sought data and information for the report. We hope the results reported and recommendations made will contribute to the improvements in operations of the respective value chains, and hence lead to enhanced livelihoods for the actors. Finally, for KALRO management and support staff, we acknowledge your service and logistical support.

Summary

The history of mechanisation in sub-Saharan Africa stretches back to the late 1800s when animal traction was used for production of cash crops such as cotton, rice, and groundnuts among others. In Kenya, mechanisation started with the use of animal traction on small holder farms in Nyanza in the 1920s. It spread further due to the introduction of tractors in the post-war years. Mechanisation describes the tools, implements and machines used to improve the productivity of farm labour and can be powered by hand and draft animals or motorised. Owing to a rapid population increase, it is critical to improve productivity of crops such as rice and bananas; this is possible through mechanisation and social-organisational innovations. Due to inadequacy of information on the level of mechanisation of the two crops, this study was initiated to assess the status, challenges, and prospects of agricultural mechanisation on rice and bananas in Kenya. The study was conducted in Kirinyaga County on rice and bananas and in Kisumu County on rice. We used qualitative and quantitative methods and interviewed 247 farmers comprising 182 rice and 60 banana farmers respectively. Ten key informant interviews were conducted in Ahero and nine in Mwea Rice Schemes and the surrounding areas. One focus group discussion was held with Mwea *Jua Kali*/Valley bottom farmers. The data were analysed using descriptive statistics, frequency analysis and cross tabulations. Descriptive and frequency analysis involved use of the sample mean, frequency, percentages and figures on demographic variables. Cross tabulations were used to compare the relationships between the socio-economic characteristics of the respondents and mechanisation levels among different groups within each site and between different sites. Results showed that in Ahero, mechanisation was mainly in land preparation, milling and transportation while in Mwea it was in land preparation, crop protection, harvesting, and milling. Mechanisation for bananas was in land preparation, irrigation, transportation and value addition. The main challenges were lack of information; planting by broadcasting seed; low prices of paddy rice; bird damage; and low-priced rice imports. Opportunities for rice and banana mechanisation exist; they include strengthening stakeholder configurations such as public-private partnerships, increased access to credit, regulation of rice imports, and standardisation of machinery imports. In conclusion, there is need for more mechanisation in critical rice and banana value chain production stages such as transplanting and weeding in rice and harvesting and value addition in bananas.

Key Words:

Mechanization, Standardization, Agricultural productivity, Rice, Banana

Introduction

In Kenya, the agriculture sector accounts for 65 percent of employment, 75 percent of domestic trade, and 60 percent of export earnings; its performance affects the performance of the whole economy (GOK, 2015). This is mostly through small holder production that accounts for 75 percent of the total agricultural output and 70 percent of marketed agricultural produce (ASDS,2010). However, the sector is characterised by low agricultural mechanisation and drudgery within the crop and livestock production and post-harvest operations, leading to low productivity. Owing to the increase in population and the fast rate of urbanisation, there is need to modernise agriculture and food production through agricultural mechanisation in agricultural value chains (Takeshima and Salau, 2010; ASDS, 2010).

Agricultural mechanisation is defined as the application of tools, implements, and powered machinery as inputs to achieve agricultural production using manual, animal, and motorised power (Clarke and Simalenga, 1997). It involves shifting to an alternative combination of the use of land, capital, and labour to improve farm incomes through increased output, reduced costs, or both, with an additional non-monetary benefit being reduction in the drudgery of farm work (Karim *et al*., 2013). An important factor of production is farm power which has largely remained human based, leading to low farm mechanisation (Takeshima and Salau, 2010; Mrema *et al.,* 2007). This is aggravated in smallholder farms whose source of energy has remained predominantly manual human labour (ASDS, 2010).

Various efforts have been made in the past by African governments and donors to accelerate agricultural mechanisation with mixed results due to the fragmented and diminishing farm sizes. In Kenya, the productivity of rice and banana value chains have potential for further improvement through mechanisation and social-organisational innovations. However, to understand the current status of mechanisation in these value chains, it is important to understand past efforts that included the introduction of animal traction and tractors and their links with current government efforts.

Literature Review

Agriculture in sub-Saharan Africa (SSA) has evolved through several phases from the days of hunter gatherer existence to sedentarisation, following domestication of plants and development of simple hand tools such as sharp stones and the planting stick (Blench, 2006). The introduction of iron from local iron ore deposits and/or recycling from industrial scrap metals led to iron smelting as a major economic activity and in turn caused a major revolution in agriculture. Production of knives (machete, cutlass or 'panga'), axes and hand hoes led to opening up of former forests and savanna to give way to crop land and associated structures such as ancient canals and dykes. Possibly, these hand-powered tools were the earliest forms of mechanisation and have continue to exist to date (Pingali*et al.,* 1987; Blench, 2006; Karim*et al.,* 2013).

Later, the ox-drawn plow and other implements were introduced, further enhancing the efficiency of farm operations; however, their use was limited by various factors, especially those related to the health of the oxen. Animal traction in SSA was used between the 1880s and the 1930s for paddy rice cultivation using the mould board plow in Madagascar, Botswana, Guinea, and Sierra Leone (Pingali *et al.,* 1987). In Northern Nigeria, they used ox-drawn ridgers while in Senegal, ox-drawn seeders were used for groundnut production. In the 1920s, use of animal traction also spread to the Lake Victoria periphery in Nyanza Province, Kenya, Sukumaland in Tanzania, and Teso District in Uganda, mainly in the rapidly expanding cotton and maize production. For example, in 1924 the number of plows in Teso rose from 282 in 1924 to 15,388 in 1937. Concurrently, acreage under cotton production increased from 84000 to 158878. (Pingali *et al.,* 1987).

However, several other efforts to introduce animal traction failed due to various reasons--areas were under forest, land was under bush fallow or had inappropriate farming intensities that determined profitability. Poorly developed veterinary services, inappropriateness of imported equipment and the low understanding by local farmers on profitability of recommended operations obstructed rapid uptake (Karim*et al.,* 2013; Pingali *et al.,* 1987). Further, spread of the animal draught power initiatives were curtailed by the introduction of tractors in the post-war years that continued into the independence years of many countries (Pingali *et al*., 1987).

Initially, tractors were used mainly on settler- and government-run farms. However, after 1945, African farmers began using tractors where tractor imports were financed by the farm machinery funds allocated through the Marshall Plan (Mrema *et al.,* 2007, Pingali *et al*., 1987). Between 1945 and 1981, there were three distinct waves in the introduction of tractors and quiet periods in between.

The first generation of tractor users were Zimbabwe, Kenya, Zambia, and Malawi around 1945 while the second generation users were Tanzania, Ethiopia, Ghana, and Cote d'Ivoire between 1958 and 1970. That time, tractors were provided through cooperatives and state firms, or tractor-hire services (Karim *et al.,* 2013, Pingali *et al.,* 1987).

However, the increase in tractor numbers later slowed down as a consequence of the conclusions drawn from socioeconomic studies conducted in the 1960s, which indicated that tractors caused unemployment, thus influencing policy makers and donors (Mrema *et al.,* 2007). As a result, tractor numbers in SSA declined to 221,000 although in Asia they increased to 6 million by the year 2000 (Mrema *et al*., 2007). The structural adjustment programmes in the 1980s and 90s also led to further suppression of the tractor numbers as governments pulled out of schemes such as the Agricultural Mechanisation Services (AMS) with the assumption that the Private Sector would take it up. However, this failed to happen in most cases except where there was proper planning and management. Currently, the average number of tractors in SSA is about 28 per 1000 ha of arable land; in Kenya, the average is 2.5 per 1000 ha, which means that 50 percent of farm work is manual (ASDS,2010; FAO, 2008). Mechanisation, like other inputs, has a cost implication requiring an initial capital investment apart from the operational

costs such as fuel, servicing, and maintenance. All these services are provided by different actors who require to be appropriately involved, for mechanisation to effectively take place (Karim*et al.,* 2013).

Rationale for the Study

Farm operations in Kenya overwhelmingly rely on human muscle power using the hoe and other hand tools, thus limiting the energy and operational output. With the increase in the Kenyan population, food consumption has also increased. For example, the per capita consumption of rice has increased from 3.4 kg in 1980 to 55.5 kg in 2014 (ASDS, 2010). Consequently, a total of 400,000 tons of rice must be imported since the 45,000–80,000 metric tons produced cannot feed the population. Conversely, manual rice production leads to delays in operations and poor work quality.

Bananas have also rapidly gained importance where value addition has significantly improved farmers' incomes. There is an opportunity for mechanisation to increase yield per unit area in addition to facilitating value addition for increased income and shelf life. As a result of this opportunity, there was need for a baseline study to establish the status, challenges and prospects of agricultural mechanisation in the two crops.

Methodology

The study was conducted in Kirinyaga (Figure 1) and Kisumu (Figure 2) Counties. Both are major rice-growing areas; the rice is grown under irrigation with diverse socio-economic environments. In Kirinyaga, the study on rice mechanisation was undertaken in the Mwea Irrigation Scheme while that for banana was conducted next to the scheme in Mwea East and West. In Kisumu it was carried out in Ahero Irrigation Scheme.

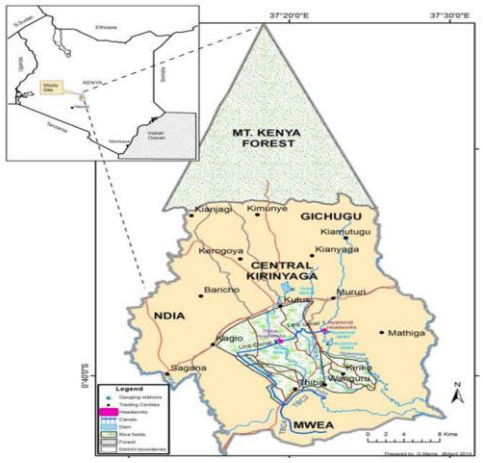

Figure 1: Mwea Irrigation Scheme

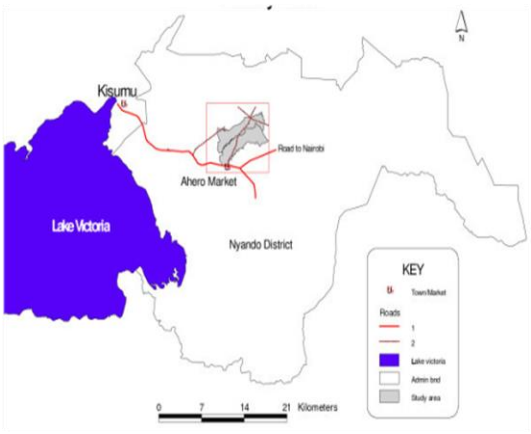

Figure 2: Ahero Irrigation Scheme

Site description

The Mwea Irrigation Scheme is part of the Kenya National Irrigation Board's Eastern Regional project situated in Mwea East and West sub-Counties of Kirinyaga County. The county is approximately100 km North-East of Nairobi (0°40'S; 37°18 ' E), at an altitude of 1159 m (Figure 1). The scheme covers about 13,640 ha, of which 8,000 is under rice cultivation. The rest of the scheme is used for settlement, public utilities, subsistence, and farming of horticultural crops. The scheme is developed on gazetted land where each farmer was allocated 1.6 ha. However, due to population increase, most of the holdings have been subdivided among family members and transferred to new farmers in some cases. The scheme is served by two main rivers, Nyamindi and Thiba that serve 80 percent of the scheme. Irrigation water is abstracted from the rivers by gravity using fixed intake weirs, and is conveyed and distributed in the scheme via unlined open channels.

Ahero Rice Irrigation Scheme is part of the Kenya National Irrigation Board's Western Regional project and is situated on the eastern margin of the Winam Gulf of Lake Victoria, 20 km east of Kisumu City between 0°07'S and 09'S and between 34°54'E and 34°58'E (Figure 2). The scheme covers 878 hectares divided into 12 irrigation blocks ranging from 31 to 115 ha with a total of 533 farming households, each allocated a 1.6 ha of paddy-field. The irrigated area is supplied with water from River Nyando, where rice is planted in two seasons annually. The seasons often coincide with the local rainfall patterns; one crop is harvested in July and the other in January.

Site selection and households interviewed

The counties and respective irrigation schemes were purposively chosen (main irrigated rice producing counties and schemes). The schemes were clustered into four to six areas and the households (HH) interviewed were randomly selected. These households were selected proportionately based on the population of farming households for each cluster/area (Table 1).

Table 1: Number of households sampled

Ahero		**Mwea**	
Name of cluster	**No. of HH**	**Name of cluster**	**No. of HH**
Scheme	35	Rice Scheme	34
North Kano	50	Outgrowers	15
West Kano	15	JuaKali (Valley Bottoms)	17
South West Kano	15	Mwea West	21
Nyachoda	10	Mwea East	28
		Kirinyaga Central	8
Total	**125**	**Total**	**123**

Three categories of rice farmers were studied depending on the location where they were undertaking their rice production. These were irrigation scheme farmers, out-growers, valley bottom/'Jua Kali' rice farmers. Scheme farmers are those located within the designated Ahero and Mwea National Irrigation Board schemes. Out growers were those producing their rice within the vicinity of the scheme although their land was formerly outside the designated scheme. Valley bottom or jua kali were farmers growing rice farther away from the scheme, mainly in Mwea; they started their rice activities after the 1999 rice rebellion.

Other key value chain actors (processors, fabricators, extension and financial service providers) available in each category were identified purposively. We interviewed 247 farmers, including 182 rice farmers and 60 banana farmers. The key informants' interviews included 10 in Ahero and 9 in Mwea. One FGD was held at Mwea Jua Kali/Valley bottom farmers.

Data collection

Qualitative and quantitative methods were used in the study while a review of literature provided the context in which the agricultural mechanisation sector was operating. Information/data that included existing policies and regulations on mechanisation, rice and banana production environments were collected from secondary sources. In addition, primary data were collected using: household survey, Key Informant Interviews (KII), Focused Group Discussions (FGDs) and observations. Data on households were captured using a structured/semi-structured questionnaire while KII and FGD were done through a checklist.

Data analysis

Data were analysed using descriptive statistics, frequency analysis and cross tabulations. Descriptive and frequency analysis involved use of the sample mean, frequency, percentages and figures on demographic variables. Furthermore, cross tabulations were used to analyse and compare results of the relationships between the socio-economic characteristics of the respondents and levels of mechanisation in agriculture among different groups within each site and between different sites.

Results and Discussions

Data on socioeconomic characteristics of the farm households, status, challenges and prospects of mechanisation in rice and banana value chains were obtained.

Age distribution of the head of household by value chain and county

The age distribution of the respondent farmers in the two counties was: 26 percent youths (aged below 36 years), 66 percent middle aged (between 36-65 years) and 8 percent the elderly (above 65 years) as shown in Table 2.

Table 2: Age distribution of the household head by value chain and county

		Youth (below 36 years)		Middle Age (36-65 years)		Elderly (Over 65 years)		Total	Mean Age	Experience in Farming (Mean)
Kisumu	Rice	38	(31)	74	(60)	12	(10)	124	45	18
Kirinyaga	Rice	20	(29)	44	(64)	5	(7)	69	44	12
	Banana	7	(13)	45	(83)	2	(4)	54	47	10
	Total	65	(26)	163	(66)	19	(8)	247		

(Number in parentheses is in percentage)*

The age of the head of the HH was normally distributed with a mean of about 45 years. The proportion of the youth was about 30 percent in rice farming as compared to 13 percent in banana farming while the respondent farming experience was at an average of 15 years in rice and 10 years in banana production.

Household size, occupation, education level, and source of income of the head of household

The average household size in Kisumu was eight members while in Kirinyaga it was five for both rice and banana farmers. Majority of the farmers in both counties and value chains had formal education with farming as the main occupation and source of income (Figure 3). The average income for 2 years (2013/14-2015/16) from their farming activities was Ksh155,971 (USD 1559.71) for each rice farmer and Ksh96,972 (USD 969.72) for each banana farmer in Kirinyaga County, and Ksh103,322 (USD 1033.22) for each rice farmer in Kisumu.

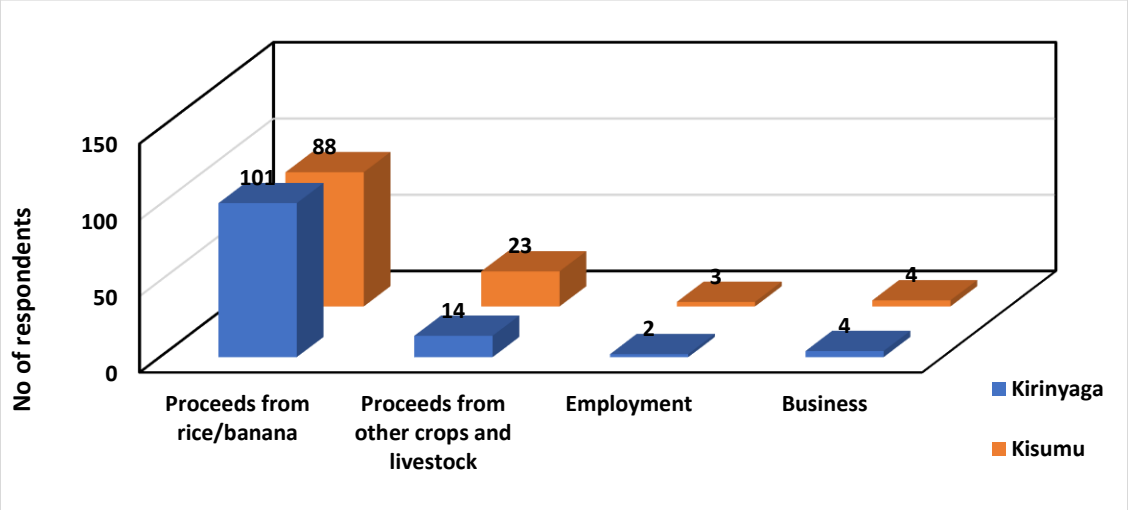

Figure 3: Household sources of income

Land ownership

The land owned by farmers in Kisumu County averaged 1.36 ha with 0.7 ha being under rice production. Rice farmers in Kirinyaga owned on average 1.09 ha and utilised 0.6 ha for rice production; banana farmers owned on average 0.97 ha with 0.34 ha being under banana production (Figure 4).

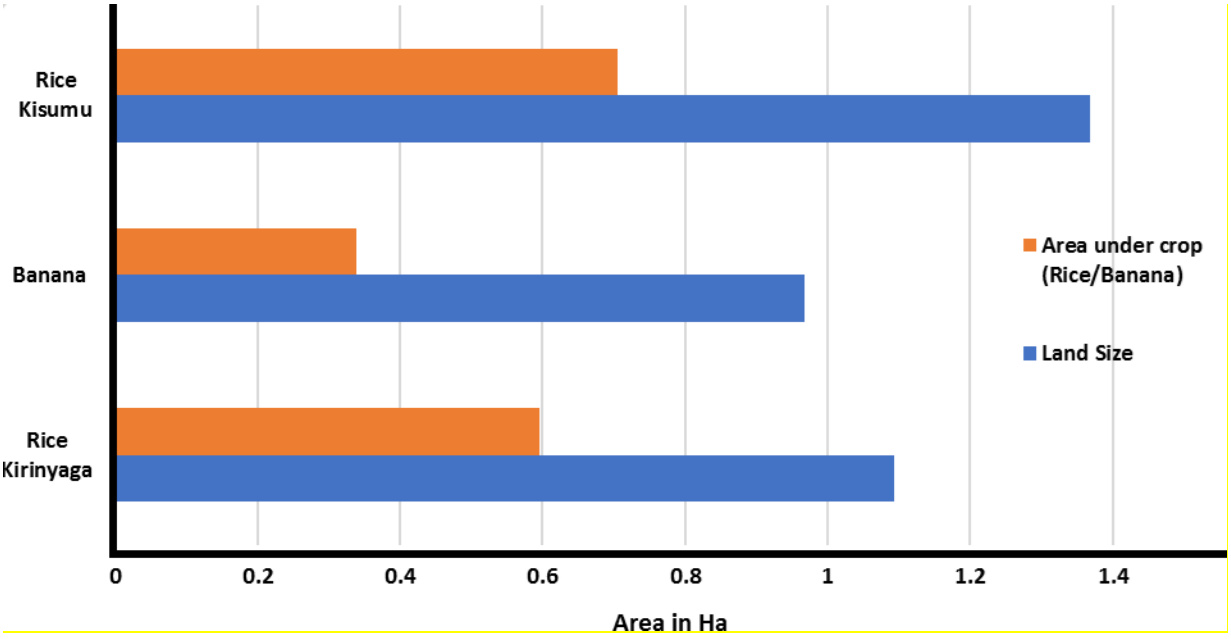

Figure 4: Land ownership and utilisation

In both counties, most farmers owned land with title deeds, creating an opportunity for them to access financial services using those titles as collateral.

Access to extension and financial services

Access to extension and financial services varied with respect to county as well as entity that was responsible for delivery (Table 3). In Kirinyaga, 11 sources of extension information were recorded while in Kisumu only 7 were recorded. In both cases, government extension services provided most of the services (43percent in Kirinyaga and 60percent in Kisumu) followed by NGOs (29percent in Kirinyaga and 15percent in Kisumu). Farmer-to-farmer extension was the third predominant source of information at 15percent in Kirinyaga and 13 percent in Kisumu. The services in both counties ranged from scheduled to unscheduled and on request.

Table 3: Access to extension services

County	Extension service provider	Percentage receiving the extension services			
		Scheduled	Unscheduled (pop in)	Upon request	Total
		N=48	N=14	N=6	N=68
Kirinyaga	Fellow farmer	4	38	0	15
	NGO	28	35	0	29
	Government Institution	51	19	100	43
	Agro vet	0	4	0	1
	Chief meetings	0	4	0	1
	HCDA	2	0	0	1
	JICA	4	0	0	2
	Kabinga banana growers group	2	0	0	1
	KALRO	2	0	0	1
	MIAD	4	0	0	2
	Rice MAP	4	0	0	4
		N=42	N=14	N=6	N=62
Kisumu	Fellow farmer	12	21	0	13
	NGO	10	36	0	15
	Gov. Institution	62	36	100	60
	AFRITEK	7	0	0	5
	Cooperative society	0	7	0	2
	Crop Bayer crop	2	0	0	2
	Revolving groups	7	0	0	3

Note: HCDA – Horticultural Development Authority; NGO – Non Governmental Organization; MIAD - Mwea Irrigation Agricultural Development Centre; JICA -Japan International Cooperation Agency; KALRO – Kenya Agricultural and Livestock Research Organization; AFRITEK – AFRITEK Seed Company.

The agricultural finance institutions available in the two counties were commercial banks, micro-finance organisations, and cooperative societies. In Kirinyaga, the most common financial institutions offering services to farmers (60 percent of respondents) were commercial banks followed by cooperative societies (35 percent). In Kisumu, they were cooperative societies (67 percent) followed by micro-finance institutions (39 percent) (Table 4). In both counties, credit (loans) was the main service sought from the financial institutions.

Table 4: Financial service providers

		Agricultural Financial Institutions within reach			
	Financial Services	**Commercial Banks**	**Micro Finance**	**Cooperative Society**	**Total**
Kirinyaga	Banking	4	0	1	5
	Farm Inputs	1	0	2	3
	Loan	60	6	35	100
	Training and advisory	1	0	0	1
	Total	**66 (60%)**	**6 (5%)**	**38 (35%)**	**110**
Kisumu	Banking	0	0	1	1
	Farm Inputs	2	3	6	11
	Grants	0	6	3	9
	Loan	8	19	23	50
	Total	**10 (14%**	**28 (39%)**	**33 (67%)**	**71**

The major reasons for not accessing financial services by farmers in Kisumu was lack of information and access to the services (40percent, N=45 for Kisumu) followed by poor governance (24 percent). In Kirinyaga the main reason was high cost of financial services (49percent, N=41) followed by repayment fears (19 percent) (Figure 5).

Status of Agricultural Machinery

Availability of agricultural machinery

Some of the available agricultural machines in the two sites included: chaff cutters, knapsack sprayers, disc plows, water pumps, levelers, millers, ox-plows, push weeders, rotavation tractors, rotavators, and sprinklers. However, only 35 percent of the farmers indicated that the dealers of these machinery were available within their areas while 48 percent indicated that they were not. Seventeen percent did not know whether the dealers were available or not (Figure 6). The average distance from the farm to the dealer was 4.57 km in Kirinyaga and 5.03 km in Kisumu. These results indicate that availability of these machinery was not widespread.
Use of machinery

There are a number of operations in rice and banana production where machinery can be used. Eight common operations were selected to determine the level of machinery use. These were land preparation, weeding, fertiliser application, pest and disease control/crop protection, harvesting, threshing, milling/processing and transportation. In the rice value chain, the most commonly mechanised operations were milling (88 percent, N=178) followed by transport (84.4 percent) and land preparation (66.7 percent) (Figure 7). Operations that might require serious interventions are weeding, harvesting, threshing, and fertiliser application

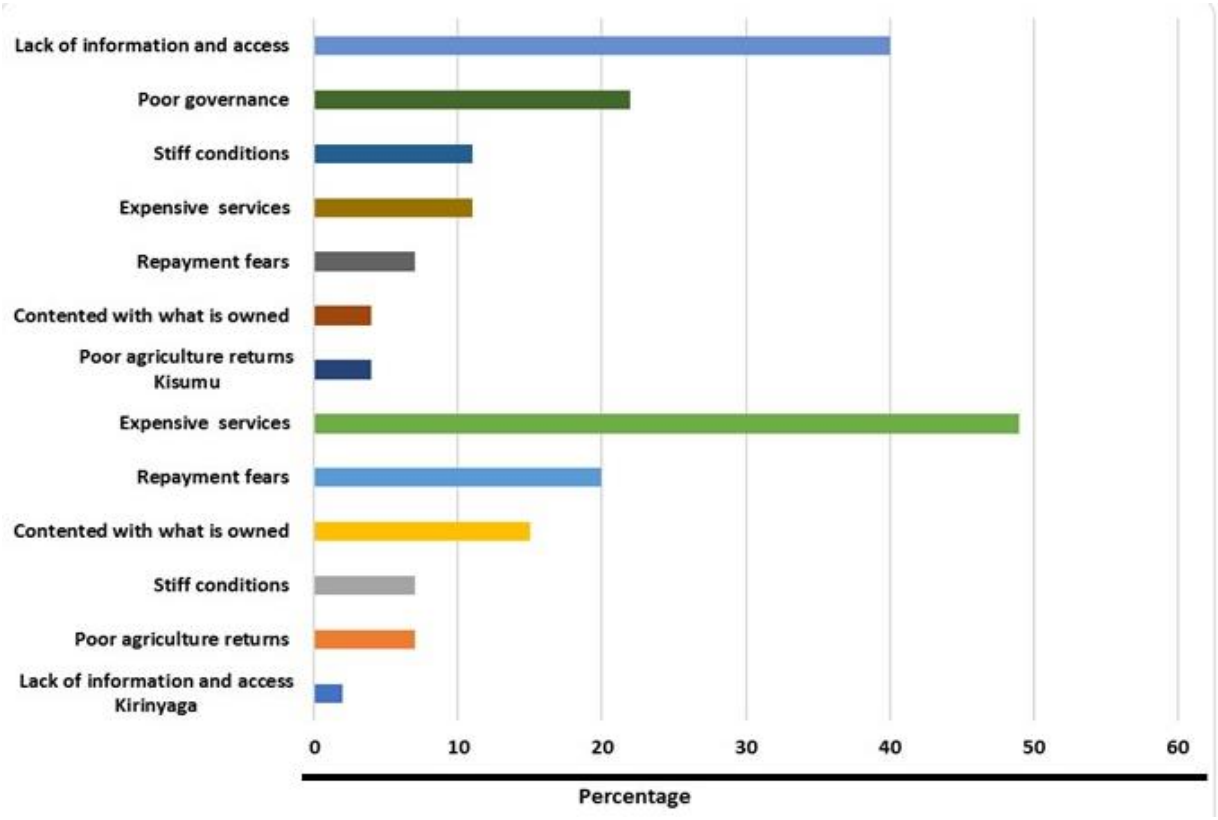

Figure 5: Reasons for not accessing financial services

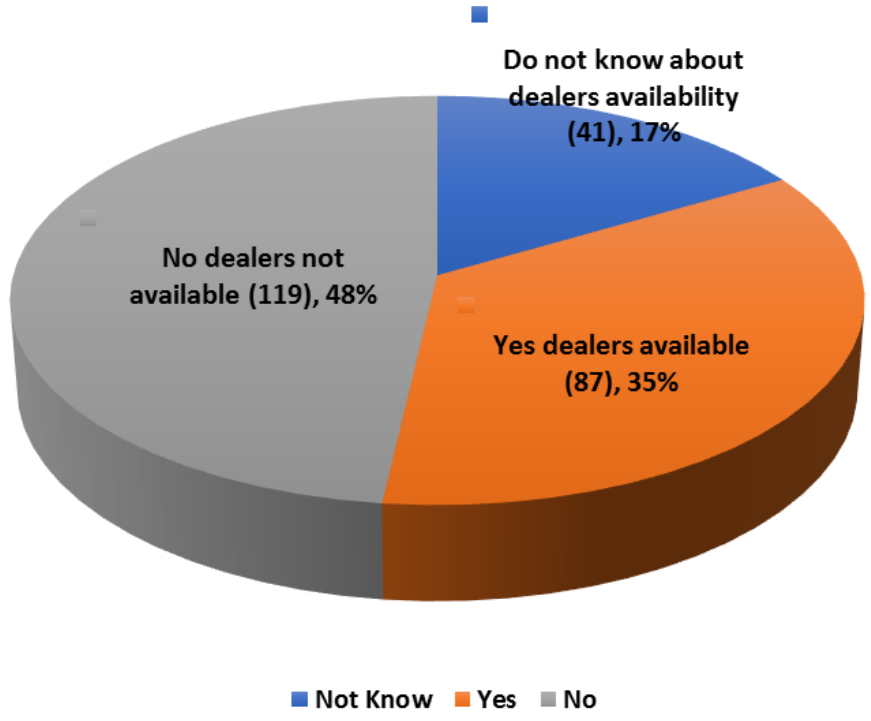

Figure 6: Availability of machinery dealer

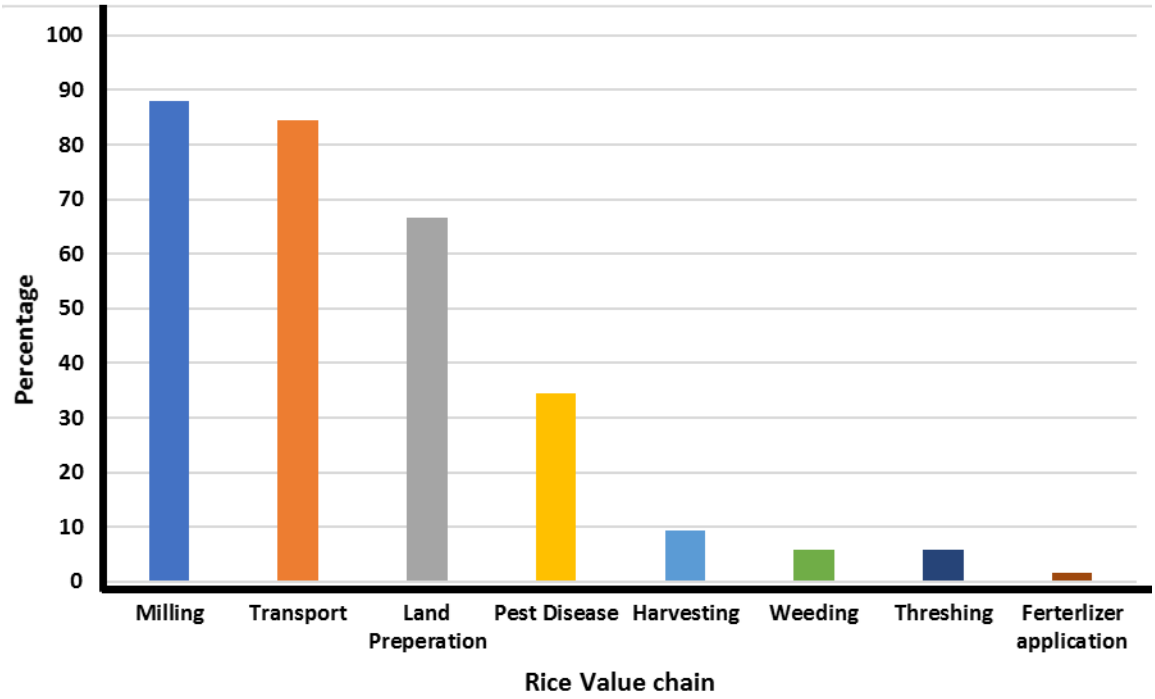

Figure 7: Mechanisation status in the rice value chain

In the banana value chain (Figure 8), mechanisation was mostly in transportation (93.2 percent) (N=54) followed by land preparation (54.5 percent), processing (27.3 percent) and pest and disease management (25 percent). There was very low mechanisation in weeding and none at all in harvesting despite the effect this can have on the quality of the banana bunches.

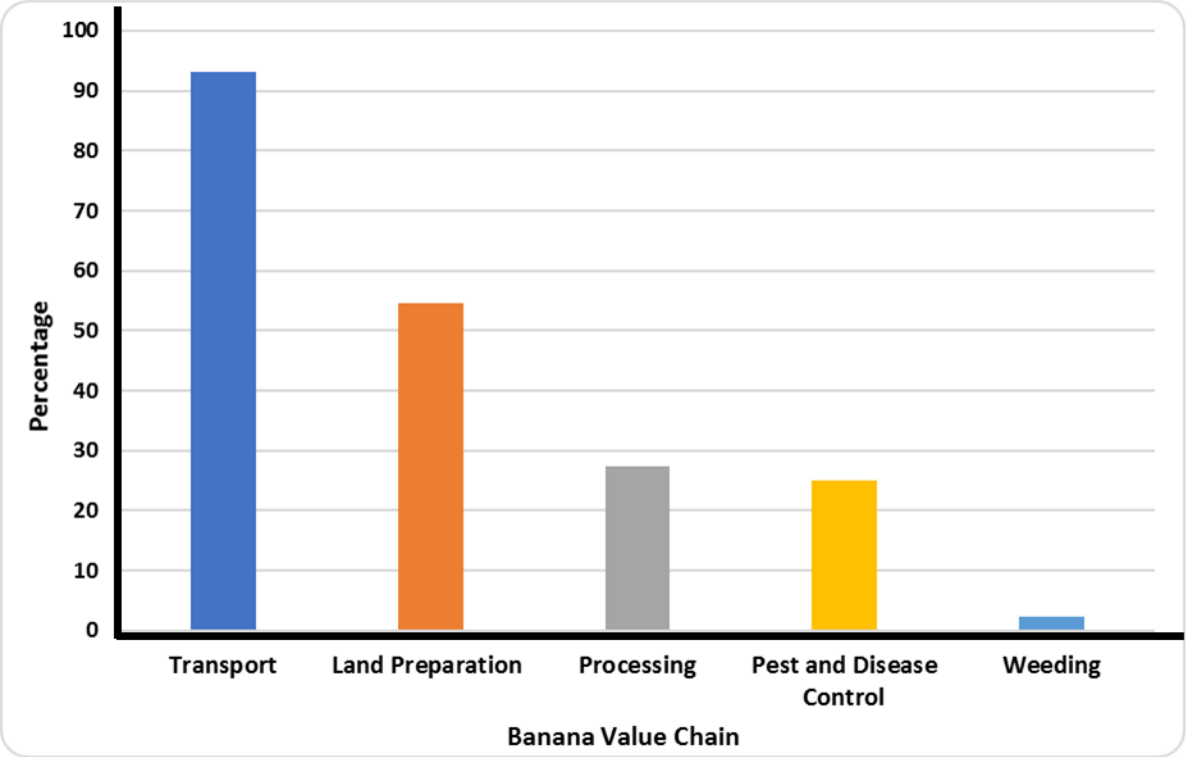

Figure 8: Mechanisation status in the banana value chain

When the two counties were compared, it was observed that processing, transportation, and land preparation were the operations that had the highest levels of mechanization, ranging from 63 to 100 percent. In Kirinyaga, 26.1 percent of harvesting was through mechanisation; this was due to the recent introduction of combine harvesters. It was observed that there was more mechanisation in transportation, land preparation, pest and disease control in Kisumu County than in Kirinyaga (Figure 9).

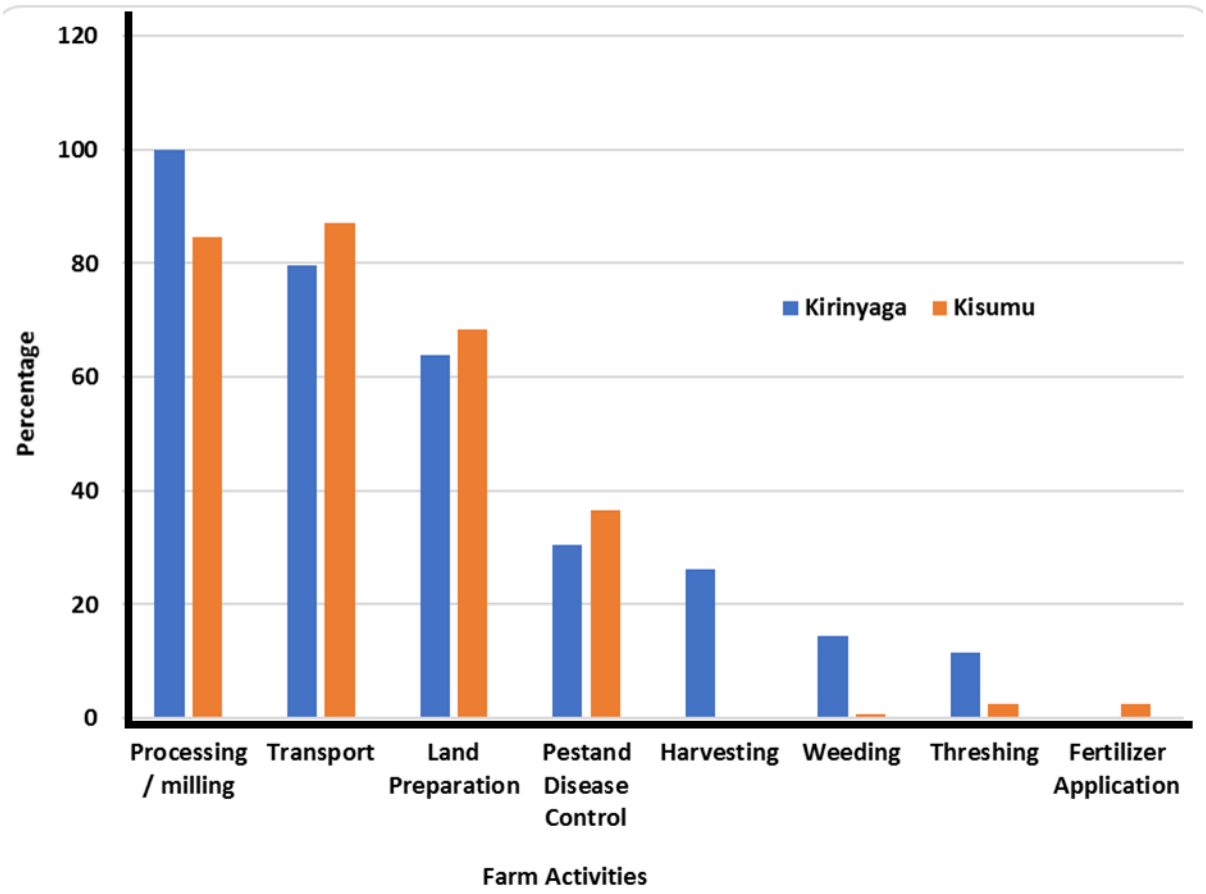

Figure 9: Status of mechanisation by county

Power source and infrastructure

Power and infrastructure are determinants of the level of mechanisation. It is expected that availability of power contributes towards the use of some of the machines in agricultural production. In Kirinyaga, the source of power was mostly from the electric grid (40 percent) followed by solar panels (34 percent); in Kisumu, it was mostly from kerosene (30 percent) followed by the electric grid (27 percent) (Table 5).

Table 5: Sources of power for farm machinery in Kirinyaga and Kisumu

	County where the farm belongs	
	Kirinyaga (percent)	**Kisumu (percent)**
Main Electric Grid	40	27
Solar Power	34	23
generator	2	12
Firewood	2	6
firewood	2	0
kerosene	17	30
Total	N=123	N=124

Processing

There are about 25 rice mills in Kisumu County and about 140 in Kirinyaga County. These range from small, medium, to large depending on the milling capacity. Small mills have a capacity of milling below 2 tons per day; examples are Ombeyi and Ogwedhi Rice Millers. Medium mills have a capacity of milling 2 to 20 tons per day; examples are Nyamunga Rice Millers. Large mills have a capacity of milling over 20 tons per day; examples are: Western Kenya Rice Millers and Lake Basin Rice Millers in Kisumu, and Nice Millers in Kirinyaga. However, large millers buy paddy rice only from farmers that meet stringent quality standards including having a maximum moisture content of 13 to 14 percent, 2 percent impurities and 6 percent pre-mature content. The other millers have no clear guidelines on the quality of paddy rice they require for purchase except for dryness.

Challenges in production, processing, and marketing prohibiting agricultural mechanisation

Challenges by actors

Several challenges in rice and banana production, processing, and marketing affect the value chain actors, thus limiting adoption of mechanisation. The actors include: Farmers

During land preparation, rice farmers faced challenges with ploughing and rotavation due to heavy soils and the poor road and irrigation infrastructure that limit mobility of tractors in the field. Banana farmers also faced difficulties in ploughing and maintenance of the tractors. The challenge was further compounded by limited availability of machinery and equipment.

At planting, farmers lacked good quality banana planting materials and rice seeds. This challenge was worsened by limited volumes of irrigation water due to poor maintenance of water canals despite the levy charged for maintenance. Inadequacy of irrigation water led to reliance on rains by the banana farmers leading to low yields. This also applied to rice farmers in the lower reaches of the rivers supplying water to the schemes in Ahero and Mwea.

At weeding, a major challenge in rice was the high cost of the operation because initial weeding alone required 16 man-days per acre at the rate of Ksh400 (USD4) per person, totalling Ksh6,400 (USD 64). When three weddings were conducted, the expenses totalled Ksh19,200 (USD 192). This cost could be reduced by using the rice push weeded, which requires 5 man-days to weed an acre of rice at a cost of Ksh2000 (USD 20); however, haphazard planting is a major hindrance to its use.

At grain filling stage, respondents cited *quelea* bird damage as a major challenge that led to huge losses owing to their large numbers. To mitigate these losses, farmers require bird scares from dawn to dusk, which is costly. The government no longer provides spraying services against *quelea* birds.

At harvest, farmers faced difficulties in transporting reapers and threshers, thus limiting their use. Manual rice harvesting led to huge losses due to gleaning, which is a social norm. Appreciable amounts of rice grain are left in the rice straw by the hand labourers who then inform the gleaners on the status of the straw. The recent use of combine harvesters has led to recovery of three extra bags per acre, all of which were being recovered by the gleaners.

At drying time, respondents cited the problem of over drying, which leads to broken grain. High labour requirements at drying time were cited as a constraint since the produce has to be spread out in the morning and gathered in the evening. This makes the farmers sell their grain immediately after harvesting at low prices. For banana farmers, a major challenge cited was lack of harvesting machines or mechanised tools that could be used for harvesting. For this reason, bananas are harvested manually; this leads to bruising of the bunches, thus reducing the shelf life of the ripened banana as well as lowering its appeal to buyers.

Millers and processors

A major challenge faced by processors was occasioned by the erratic supply of paddy rice received from farmers. When the supply was low, the milling capacity was underutilised; when it was high, the capacity was overstretched.

Another challenge was competition for paddy rice especially from Ugandan buyers (in the case of Ahero) who purchase it irrespective of its quality, at more competitive prices. Other challenges included the poor quality of paddy rice received from farmers due to failure by farmers to observe good agricultural practices. Low quality rice leads to low profitability for millers, resulting from further drying expenses and/or cheaper low-grade rice milled. This is

exacerbated by the high cost of milling due to high energy and maintenance costs, inadequate working capital, and inadequate demand for locally milled rice due to availability of cheaper imported rice.

Respondents mentioned that some millers were unfamiliar with the adjustments needed when different types of rice grain were delivered for milling. They also said they lacked finances to enable them to buy bulk rice for sale at a later stage. However, they have attempted to address this challenge through collective purchase with other millers.

Banana processors cited the challenge of manual processing, which leads to slow work and poor-quality products. Another challenge was lack of Kenya Bureau of Standards certification. Without the certification, their processed products cannot be sold in super markets and other outlets. An additional challenge was the low demand for banana fruits and crisps during the mango harvesting season due to the buyers' preference for mangoes over bananas.

Loans for buying banana processing equipment were not readily available. In the few cases where bananas were being processed, machines were procured collectively or provided through projects.

Fabricators

The fabricators were unable to express their concerns collectively since they operated individually. They were constrained by: the high cost of raw materials needed for fabrication; the low demand for fabricated equipment and machinery due to lack of farmer sensitisation on the drudgery-saving machines such as the rice weeder. The fabricators also received very little support from industry regulators such as Kenya Industrial Research Development Institute (KIRDI) and Kenya Intellectual Property Institute (KIPI) to guide on Intellectual Property Rights. They also cited the challenge of lack of space to display and popularise their products.

Another challenge faced by fabricators was mobility of skilled personnel who would move on and start their fabrication business once fully trained. They encountered resistance initially, from politicians and activists, who perceived ill motives in the machinery introduced.

Financial Institutions

The financial institutions included Agricultural Finance Corporation (AFC), Barclays Bank, Kenya (BBK), Equity Bank, and SACCOS such as Century Finance.

Challenges faced by financial institutions in both rice and banana value chains included the attitude of clients that loans would be written off by the government. This was partly attributed to inadequate sensitisation on provision and terms of financial services. It was also reported that the low prices offered for paddy rice after harvesting due to inadequate storage resulted in low rice profitability and hence low demand for rice loans. Some banana-growing groups have started accessing loans from SACCOS like Century Finance, which offers loans at reasonable interest rates. The groups did not have sufficient information on financial products available to

farming clients; this dampened demand for such services. The farmer groups were poorly managed, which reduced access to machinery.

Cross cutting challenges

Machinery import policy

One of the cross-cutting challenges to farmers, fabricators, and the processors was the low or lack of adherence to machinery importation policies. This led to importation of sub-standard equipment and machinery, hence suppressing local production. These actors expressed a need for a policy on importation of these machines since haphazard supply of equipment/machinery creates problems due to lack of spare parts and service.

Loans (Financing)

Farmers, fabricators, and processors cited the fear of taking a loan because of unfriendly follow up by the loaning agents and also fear of the assets being auctioned. There was a challenge of wrong perception by farmers about loans where they assumed that the loan money was government money that should not be repaid. Some farmers lacked collateral in the form of title deeds; this denied them access to loans.

Low awareness on available machinery

Respondents in both study sites cited the challenge of low awareness on available machinery options. This was attributed to the low number of extension agents who are mostly unskilled and lack specialisation on agro-equipment and knowledge on the linkages between agriculture, irrigation, and agricultural mechanisation.

Inadequate funding to fabricators and research project

Fabricators cited the high registration fees, which were unaffordable to the small fabricators; they also cited bureaucracy in the government procurement process. Other concerns were the lack of sustainable funding for research projects and inadequate finances to carry out mechanisation operations. An example was cited where a rice transplanter and other equipment were supplied to the research centre but no funds were availed to conduct field trials

Prospects/opportunities of rice and banana mechanisation in Kirinyaga and Ahero

The actors in the value chains studied in the two sites encountered challenges that require to be addressed over time. However, other challenges have immediate technical, social-organisational and institutional solutions that can be deployed. But for the solutions to be successfully deployed, concerted efforts are required from all public and private actors in the value chains. This is in line with Karim *et al. (*2013) who concluded that unlike inputs such as seed and fertiliser, success in mechanisation requires many stakeholders and includes technical, economic, social, and environmental considerations. A suitable configuration of stakeholders

such as public private partnerships is necessary in both Mwea and Ahero to improve the level of mechanisation and address the many challenges that face rice farmers. This also applies to the banana value chain where the relevant actors ought to work together for the successful operation of the value chain.

Very low mechanisation was observed in rice transplanting, weeding, fertiliser application and irrigation/drainage and in banana transplanting, harvesting, and processing, which are key stages in these two value chains. Mechanisation of these stages will therefore be crucial towards unlocking the yield potential of the rice and banana value chains. An important observation is that the challenges to be solved in many cases are interlinked with other issues. An example is the popularisation of the push weeder, which will be futile if farmers do not plant in rows (compare Mwea and Ahero). Other cases are the low use of combine harvesters in poorly drained plots with poor road infrastructure as well as the low adoption of the reaper-thresher combination due to transportation difficulties. If harvesting bananas is not mechanised, farmers will continue to get low prices. Lack of processing will also hurt the farmers, as they will continue to sell raw bananas and hence get low prices due to perishability.

Manual land preparation is laborious, takes much time, and is costlier, leading to delays in operations for both rice and bananas; land preparation using tractors ensures timeliness. The rate of mechanisation of this operation is expected to rise but demonstrations similar to the ones by the Rice-MAPP project are necessary in the different parts of the rice-growing areas. Additionally, farmers could form agricultural innovation platforms (AIPs) as organisational structures aimed at addressing the value chain's mechanisation issues. The platforms will need to draw members from the farmers and all actors in the value chain; this will facilitate faster response to issues that arise. A monitoring committee of the Innovation Platform would ensure that the operations are implemented as expected. It will also facilitate collective procurement of small machineries appropriate for the small holder farmers. The approach described for land preparation could also be applied to transplanting of both bananas and rice. In bananas, digging holes, weeding, and processing could be mechanised for efficiency and enhancement of product quality. Trials on the rice trans-planter and its fabrication should be done to improve this operation.

Policy implications

To contribute to improved mechanisation in Kenya, policies and regulations are necessary to enhance actor access to machinery, commercialisation of fabricated and imported machines, and standardisation of machines in use. Challenges faced by farmers in accessing farm machinery limit farm productivity. One of the ways to increase access to farm machinery is to consider reducing taxation on imported machinery. Incentives are also needed to increase the capacity of farmers and millers to access the machines through awareness creation, formation of cooperatives in order to access subsidised machinery group financing, and improving farm productivity among other measures.

Access to agricultural machinery and after sales services are lacking in both counties. One of the reasons for this is low numbers of private fabricators and other machinery dealers outside those supplied by NIB and the County Governments in the targeted rice regions. This is the case particularly for Kisumu County. The low availability of the dealers is due to low demand for the machines fabricated. Mechanisms are required to encourage private sector participation. In the case of Kirinyaga, private sector participation is already increasing but incentives to enhance and sustain the momentum are critical.

The study also revealed that linkages between the Agricultural Mechanisation Services (AMS) in counties and the respective irrigation schemes were few and should be increased. Furthermore, other industry players such as KIRDI and KIPI did not seem to have clear regulations and standards on machines fabricated or imported for use in rice and banana value chains.

Conclusions

Use of mechanisation varied with type of operation for each of the value chains. The most mechanised operations for rice in Ahero were transportation and milling. In Mwea, most mechanisation was in land preparation, harvesting, and milling. In the case of bananas, the most mechanised operations were land preparation, transportation, and to a limited extent, processing and value addition. Value chain actors experienced several challenges. The main ones were inadequate information on mechanisation, low productivity due to poor agronomic and management practices, and low prices of paddy rice due to rice imports. In addition, millers incurred high costs due to high energy costs and high costs of spare parts and maintenance. Farmers had a shortage of working capital. This led to low farm productivity and lack of a clear policy and regulations on mechanisation; this partly affected the level of mechanisation.

Actors also faced several operations-specific challenges. They included availability of appropriate equipment and machines, management of water for irrigation, and a bird menace.

Despite the several challenges that the value chain actors faced, there are opportunities for upgrading the specific vale chains with direct or indirect benefits to mechanisation. In the case of rice, product diversification can be enhanced at the milling stage. While yarn for fabric can be extracted from banana pseudo stems. Other opportunities include enhancing public-private partnerships so as to enhance awareness and information sharing with regard to mechanisation, access to financial and extension services, and formation and governance of value chain actors, specifically farmers and millers.

The findings of this study therefore lead to an overall conclusion that actors meet many challenges in the quest to mechanise operations in the rice and banana value chains. A need therefore exists for all stakeholders and especially the county governments and the private sector to work together towards realising this objective. This would in turn enhance the productivity and profitability of these two important value chains in the respective counties.

References

1. Agricultural Sector Development Strategy (ASDS) 2010-2020. 2010. Agricultural Sector Ministries, Nairobi, Republic of Kenya
2. Blench, R. 2006. African Agricultural Tools: Implications of Synchronic Ethnography for Agrarian History. Paper Presented at: 5th International Workshop for African Archaeobotany London,1st – 4th July 2006
3. Clarke, L.J. and Simalenga, T. 1997. Farm Mechanisation and Strategy Formulation in East and Southern Africa in Proceedings of FAO/FARMESA Regional Workshop, 30 September. Retrieved December 3, 2006
4. FAO. 2008. Agricultural Mechanisation in Africa- Time for Action.United Nations Industrial Development Organisation, Vienna
5. Government of Kenya (GOK). 2015. Agricultural Mechanisation Policy, Kenya (draft)
6. Houmy K, Clarke, L., Ashburner, J.E, and Kienzle, J. 2013. Agricultural Mechanisation in sub-Saharan Africa: Guidelines for preparing a strategy. vol 22, 2013. Plant and Food Production Division FAO, Rome
7. Mrema, G, Baker, D. and Kahan, D. 2007 Agricultural Mechanisation in sub-Saharan Africa – Time for a New Look
8. Nagler, J. 1994. Interpreting Probit Analysis. New York University.
9. Pingali, P., Bingot, Y., and Binswinger, H.P. 1987. Agricultural Mechanisation and the Evolution of Farming Systems in sub-Saharan Africa. John Hopkins University Press
10. Takeshima, H and Salau, S. 2010. Agricultural Mechanisation of Smallholder Farmers in Nigeria, Policy Note 22
11. World Bank. 2008. Agriculture for Development. World Development Report (2008).