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A Comparative Study on the Determinants of the Level of Mechanization in Kenya: The Case of Rice and Banana Value Chains

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Introduction

Background of the study

Agricultural mechanization is one of the main factors that contribute to increased agricultural production output per farm worker. This means that a smaller workforce is required to produce the same output (Lagat *et al*., 2007). For example, in the United States, in 1950 one farmworker produced enough food to support three other people while in 1970, because of mechanization one farm-worker supported 11 people (Wennblom, 1974).

Rice (*Oryza sativa*) is the third most important staple food crop in Kenya after maize and wheat. It is mostly grown under irrigation by small scale farmers and managed by the National Irrigation Board (NIB) Scheme, although there is also non-irrigated NIB and rainfed rice. The four major NIB schemes include Mwea in Central region, Bunyala in Western, Ahero and West Kano in Nyanza regions respectively. In Ahero irrigation scheme, rice is mainly produced by smallholder farmers (GoK, 2008) which is the same way it is produced in the Mwea Scheme.

Banana is also one of the major horticultural crops in Kenya providing income and food security, as well as employment. Its growing zones range from Coastal Lands to Lower Highland zones, in particular Kisii, Kakamega, Bungoma, Meru, Murang'a, Embu, Nyeri, Kerio Valley, Kericho, Baringo, Kirinyaga and the coastal region. Other regions include Kitui, Machakos and Makueni counties as well as in the drier areas albeit under irrigation.

Mechanization levels in both the Rice and Banana value chains is variable based on type of value chain and funding initiatives. Farmers, both in the developed or developing economies, mechanize farm operations when the biological sources of energy, e.g. human and animal labour become costlier than the mechanical sources (Bidyut, 2010).

According to FAO (1996), banana productivity was estimated at 6 tons ha^{-1} in Africa as compared with 10 t ha^{-1} for the World with an existing potential of 60 t ha^{-1}. In Kenya, the average yield is 10 t ha^{-1} compared to the potential of 30 t ha^{-1} (Mbaka et al., 2008). Conversely, rice yields in Africa, are less than 3 t ha^{-1} with a potential yield of up to 15 t ha^{-1} (Mati et al., 2014) while irrigated rice in Kenya has a yield of 4.0 t ha^{-1} (MoALF, 2015). This is evidence of the unexploited potential in crop production, not only in Kenya but the rest of the world.

Overview of determinants of smallholder agricultural mechanization

Several studies have been undertaken on the determinants of mechanization on various agricultural practices (Ulluwishewa, 1987: Bidyut, 2010; Amadi *et al.,* 2013). Ulluwishewa (1987) undertook such a study to identify factors affecting the mechanization of tillage operations of paddy fields in Sri Lanka. The influence of selected socio-economic and physical factors which were considered to be effective in generating compelling grounds to use tractors for the tillage operation of paddy fields were assessed. Further, three socio-economic variables relating to shortage of labour, shortage of buffaloes and limited time available for the tillage operations which were considered crucial in determining the farmers' propensity to use tractors, were regressed on the degree of tractor utilization and the residuals from the regression mapped. The map of residuals was compared with the map of agro-climatic regions to ascertain the impact of agro-climatic conditions on tractor utilization. The results indicated that the three socio-economic variables collectively explain 51% of the spatial variation of the degree of mechanization while the map of residuals mostly coincided with the map of agro-climatic regions.

Similarly, Bidyut (2010) undertook a study on determinants of farm mechanization in modern agriculture in the Burdwain districts of West Bengal. Data were collected during the agricultural year 2005/06 by random sampling from 185 farmers in the two sub-divisions Purbasthali and Kalna of the Burdwan district. The logit model was used in the analysis where a strong positive effect was found on farm mechanization with large land holdings, proportion of High Yielding Varieties (HYVs) and fertilizer intensive crops to the total cropped and the younger generation. Other significant factors were irrigation coverage and access to institutional credit.

Amadi *et al.* (2013) also undertook a similar study in Nigeria on the factors that influence the adoption of mechanized farm technology and farm size increase among rural farmers in Nigeria. Data on methods of farm land preparation, farm size and Agricultural Development Program (ADP) inputs to rural farmers were randomly collected from 435 rural farmers between 2006 and 2009. The data was analyzed using t-test and regression analysis. The results showed that the factors that were key in the choice of farm technology were irrigation facilities, availability of credits and extension facilities.

Rationale of the study

In Kenya, despite the importance of agriculture there is generally a low level of mechanization both in livestock and crop production (KNBS, 2015; Egeru and Mwangi, 2012) where 50 percent of land preparation depended on human power, 20 percent on animal draught power and 30 percent on machines (JAICAF, 2014). This has been associated with low productivity and high cost of production which inevitably leads to low profitability in major agricultural enterprises.

According to Mrema *et al.* (2008) over the past three decades, 'not only has progress stalled in agricultural mechanization in much of South Saharan Africa (SSA), but also there is accumulating evidence that progress attained in the earlier years is being lost in many parts of the continent'. This has been exemplified by the decline of tractor hire services, and is also associated with the decimation of livestock herds by outbreaks of diseases, deteriorating animal health services and recurring droughts. This has resulted in some areas where animal traction had established a foothold reverting back to hand hoeing. Further, mechanization was dropped off the agenda of international development organizations and donor agencies, leading to its low profile in the national development programmes.

However, several African leaders and a growing number of experts in the development community, believe that to reverse this trend, mechanization should again be a policy priority in SSA. As a result, currently there are national and international efforts to give prominence to agricultural mechanization to reduce human drudgery and operation costs so as to increase productivity and income. Countries including Kenya are therefore in the process of developing policies to guide these renewed efforts to mechanization in the agriculture sector.

Mechanization has been identified as one of the major factors influencing production in the rice and bananas value chains whose productivity potential has not been exploited. Given the importance of machinery in these value chains, there was need to establish the determinants of mechanization in them. This study therefore seeks to identify factors that influence mechanization levels for rice and bananas value chains. The findings from this study will help provide technical and policy recommendations for the improvement of not only the rice and banana value chains but the entire agriculture sector.

Objectives

- To estimate the current use of machinery in rice and bananas value chains;
- To establish determinants of mechanization in rice and bananas along the entire value chains;
- Estimate the effects of the determinants on mechanization levels.

Methodology

Study methods

The study used both qualitative and quantitative approaches while the review of literature provided the context in which agricultural mechanization operates in the agricultural sector. It should be noted that, general information is scarce due to limited documentation about agricultural mechanization in the country.

However, information / data that included existing policies and regulations on mechanization, rice and banana production environments were collected from secondary sources while 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 data and information collected through KII and FGD were done through a checklist. Furthermore, observation, on spot assessment were employed to capture data and information that was not anticipated.

Study sites

The study was conducted in Kisumu and Kirinyaga Counties, both growing sizeable rice under irrigation with diverse socio-economic environments; a condition necessary for comparative analysis. In Kirinyaga, the study on rice mechanization was carried out in Mwea Irrigation Scheme while in Kisumu it was carried out in Ahero Irrigation Scheme.

Mwea Irrigation Scheme is situated in the newly created Kirinyaga South Sub-County. A total of 16,000 acres have been developed for paddy production. In addition, the scheme has a total of 4,000 acres of outgrower and jua kali areas under paddy production. The scheme is served by two main rivers namely Nyamindi and Thiba where irrigation water is abstracted by gravity through the help of fixed intake weirs, conveyed and distributed in the scheme via unlined open channels. The two rivers are linked by a canal that transfers water from Nyamindi to Thiba River which serves about 80% of the scheme. The scheme is developed on gazetted land where farmers were settled as tenants each with a holding of at least 4 acres. This acreage was based on the minimum economic acreage sufficient for the full-time upkeep of the farmers. However, due to the increase in the population, most of the holdings have been subdivided among family members and in other cases transferred to new farmers.

Ahero Irrigation Scheme is in Nyando District, in the outskirts of Kisumu City. The area is relatively dry with high temperatures. The scheme is managed by the National Irrigation Board in partnership with the farmers who are charged Kshs.3100 per acre per year for scheme Operation and Maintenance (O&M). The area under cultivation is 2168 acres which is divided into 12 blocks with a total of 1650 farmers. Nearly all irrigated farmland is used for paddy cultivation.

The site selected for banana production was Kirinyaga central, Mwea East and Mwea West bordering the Mwea Irrigation Scheme. Figures 1 and 2 show the maps of the study sites.

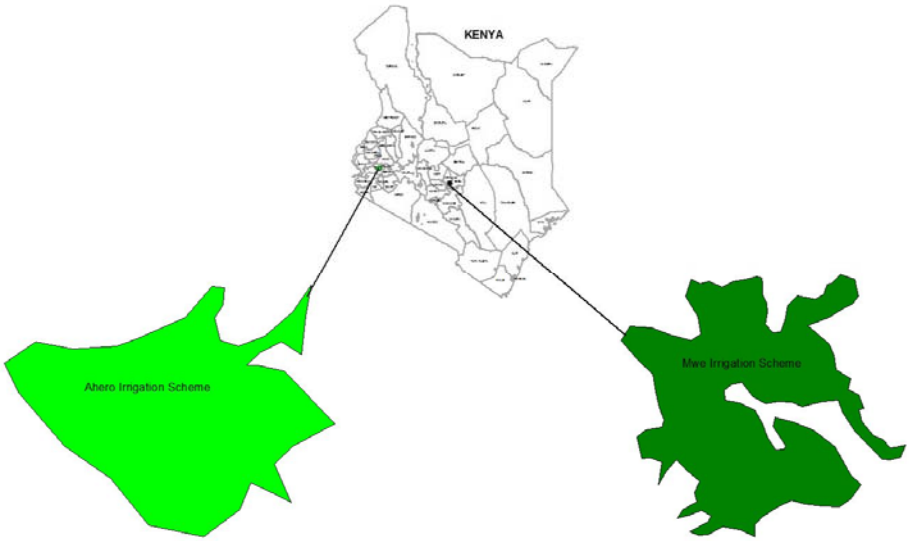

Figure 1: Mwea and Ahero Irrigation Schemes

Sampling procedure

Farming households interviewed were identified using a multi-stage sampling procedure. In stage one, counties and respective irrigation schemes were purposively chosen (main irrigated rice producing counties and schemes). In stage 2, the schemes were clustered into areas (4 - 6) while in stage 3, households interviewed were randomly selected. The number of households selected was proportionately based on population of farming households for each cluster/area. Table 1 shows the distribution of farming households interviewed.

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	Jua Kali (Valley Bottoms)	17
South West Kano	15	Mwea West	21
Nyachoda	10	Mwea East	28
		Kirinyaga Central	8
Total	**125**	**Total**	**123**

In addition, due to number of other key value chain actors (processors, fabricators, extension and financial service providers) available in each category, a select number was identified purposively and interviewed.

Data collection process

Design of the checklists and questionnaire

The questionnaire was designed to collect information on farmer-household socio-economic characteristics that were considered to be affecting the smallholder farmers' decision on whether or not to adopt mechanization. The characteristics included; size of arable land in hectares, farmers' age in years, number of years of formal education, gender, marital status, membership to farmers' associations; interest paid on credit, farming experience in years, farm income, family size (number of people in the household) at the time of interview, farm-income in Kenya shillings per annum, number of visits by agricultural extension officers the previous year, ownership of farm equipment and machinery and application of mechanization along the value chain. Further, a checklist was developed to guide in eliciting information on the status of mechanization in the selected sites through Focused Group Discussion and Key Informant Interviews.

Data collection

The questionnaires were administered to households by trained enumerators under supervision of a KALRO scientist. Ten enumerators in Ahero and five in Mwea were carefully selected and trained and pre-tested the questionnaire prior to the actual survey. They later interviewed 247 farmers including 182 rice farmers and 60 banana farmers. The key informants' interviews were 10 in Ahero and 9 in Mwea. One FGD was held with Mwea Jua Kali/Valley Bottom farmers. The completed questionnaires were inspected for completeness and accuracy each evening to ensure quality. The verified questionnaires were then taken for data entry.

Data analysis

Data were analyzed in two ways; descriptive data analysis and logistic regression analysis. From the survey, descriptive statistics on demographic information including age, gender, and marital status, size of the household and landholding sizes of the smallholder farmers was provided. Using farmers and farm characteristics, a binary Probit logistic regression model specified in Equation 1 and 2 was estimated to determine the dependency of adoption of agricultural mechanization on size of farm under rice, distance to the market, membership of a farmer's group, access to credit, age of the household head, distance to the market, gender, education, size of the household, farm income and land holding size. Both dependent and independent variables are described in Table 2.

Binary Probit Model

The difference between the logit and the Probit models lies in the distribution of errors. In logit models, errors are assumed to follow standard logistic distribution while the errors of the Probit models are assumed to follow the standard normal distribution (Park, 2006).

The Probit model further assumes that while we only observe the values of 0 and 1 for the variable Y, there is a latent, unobserved continuous variable Y* that determines the value of Y.

The other advantages of the Probit model include believable error term distribution as well as realistic probabilities (Nagler, 1994). Thus, for this study the Probit model is preferred and used.

Following Verbeek (2003), the model is specified as follows:

$y_i^* = \boldsymbol{x}_i^{'}\beta + \varepsilon_i, \quad \varepsilon_i \sim \text{NID}\ (0,1)$

y_i^* is unobserved and is referred to as a latent variable. The assumption is that an individual farmer chooses to mechanize the production of rice and/or bananas when the utility difference of mechanizing and not mechanizing exceeds a certain threshold, zero in this case, so that

$y_i = 1$ (uses mechanization) if and only if $y_i^* > 0$

$y_i = 0$ if $y_i^* \leq 0$

The decision to adopt mechanization is affected by the independent variables $x_i^{'}$ with the coefficients β. ε_i s are assumed to be independent of all $\boldsymbol{x}_i$. The independent variables (x_{1-14}) hypothesized to influence the farmer's decision to adopt or not to adopt mechanization are described in Table 2. The parameters are estimated by the maximum likelihood method.

Table 2: Model Variables

Variable	Description
Y_i	Small-scale farmers' decision to use machinery (dependent variable) which takes the value of 1 if the farmer used machinery, 0 otherwise
X_1	Size of arable land in hectares
X_2	Farmers' age in years
X_3	Number of years of formal education
X_4	Gender; 1 if a farmer is a male, 0 otherwise
X_5	Marital status; 1 if married, 0 otherwise
X_6	Membership of farmers' associations; 1 if a farmer is member, 0 otherwise
X_7	Farming experience in years
X_8	Farm income per annum KES
X_9	1 if a farmer has off-farm income, 0 otherwise
X_{10}	Ownership of machines
X_{11}	Number of visits by agricultural extension Officer of the previous year
X_{12}	1 for being a member of irrigation Scheme and 0 for out growers
X_{13}	Access to loans/credit
X_{14}	Distance to the market

Results and Discussion

Data analysis results

In this study, 247 farmers; 124 from Kisumu County and 123 from Kirinyaga County, were interviewed using a structured questionnaire to find out the status of agricultural mechanizations. All the respondents in Kisumu County were interviewed based on the rice value chain whereas respondents in Kirinyaga County were interviewed based on rice (N=69) and banana (N=54) value chains. Below are the results of the analysis of the data that was collected.

Socio-economics statistics

- Sex distribution of the head of household

  The average sex distribution of the farmers was 63% male to 37% female. A similar distribution was realized when farmers were grouped according to the value chain and Counties as shown in Table 3.

Table 3: Distribution of the Sample Households by Sex and County

		Male	Female	Total
Kisumu	Rice	75 (60%)	49 (40%)	124
Kirinyaga	Rice	45 (65%)	24 (35%)	69
	Banana	36 (67%)	18 (33%)	54
	Total	156 (63%)	91 (37%)	247

- Age distribution of the head of household and farming experience

  The age distribution of the sample households was normally distributed with a mean of about 45 years (Figure 2). Majority of the farmers were middle aged (36- 65 years) while the proportion of the youth was about 30% in rice farming compared to 13% in banana farming. The respondent farming experience was at an average of 14 years (Table 4).

Table 4: Respondents Farming Experience by Gender and County

		Youth (less than 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		

Figure 2: Age Distribution of the Sample Households

- Household size, household head occupation and education level
  The average household size for Kisumu rice farmers was 8 members while in Kirinyaga it was 5 members for both rice and banana farmers. Majority of the farmers in both counties and value chains had formal education (Table 5). Results also showed that the main occupation in the two Counties was farming.

Table 5: Household Size, Occupation and Education Level of the Head of Household

		Kirinyaga		**Kisumu**
		Rice	**Banana**	**Rice**
Household Size	Mean	5	5	8
	Minimum	1	1	1
	Maximum	11	12	28
Education level	No Formal Education	3	3	13
	Primary	41	25	68
	Secondary	20	19	35
	Tertiary	4	5	4
	University	1	2	0
	Adult education	0	0	1

Occupation	Formal Employment	2	4	3
	Farming	65	50	116
	Business	1	0	2
	Casual Labour	1	0	3

- Household income

  The main source of income in both counties was proceeds from banana and rice production respectively (Figure 3). This confirms the results in Table 5 that the main occupation was farming. The average income for two years (2013/14 - 2015/16) was Kshs. 155,971.01 (USD 1559.71) per rice farmer and Kshs. 96,972.22 (USD 969.72) per banana farmer in Kirinyaga and Kshs. 103,322.58 (USD 1033.22) per rice farmer in Kisumu.

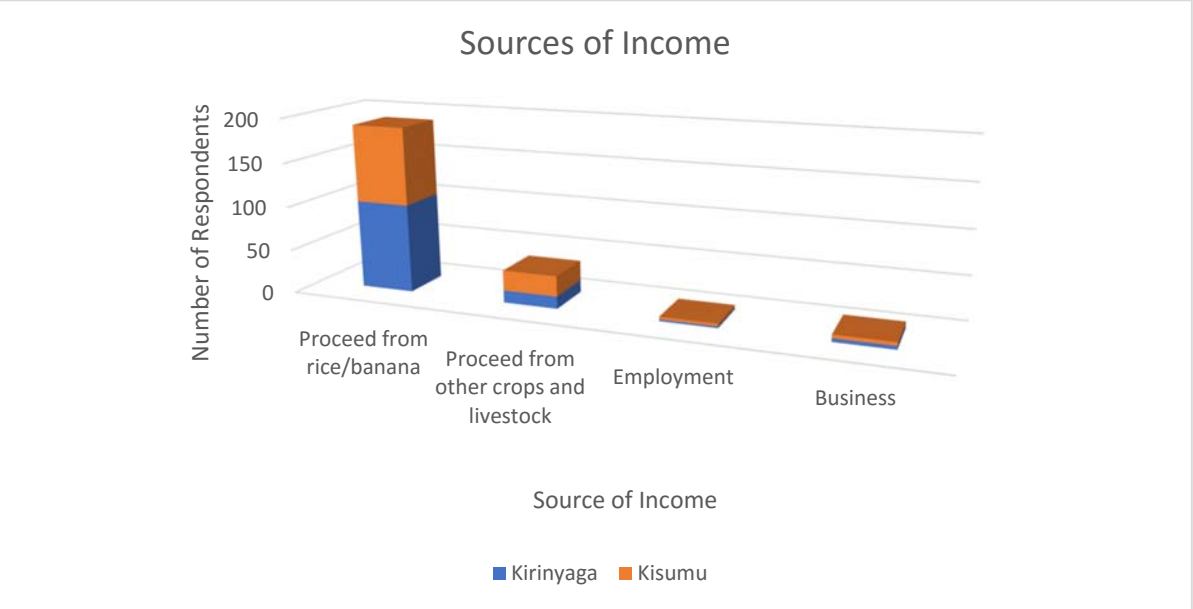

Figure 3: Sources of Income for the Sample Households

- Land ownership and use

  The results in Figure 4 below shows the area of land owned by farmers. Farmers in Kisumu County owned an average of 3.42 acres but utilized 1.76 acres on average to grow rice. Rice farmers in Kirinyaga owned an average of 2.73 acres and utilized 1.49 acres while banana farmers owned an average of 2.42 acres but utilized only 0.84 acres

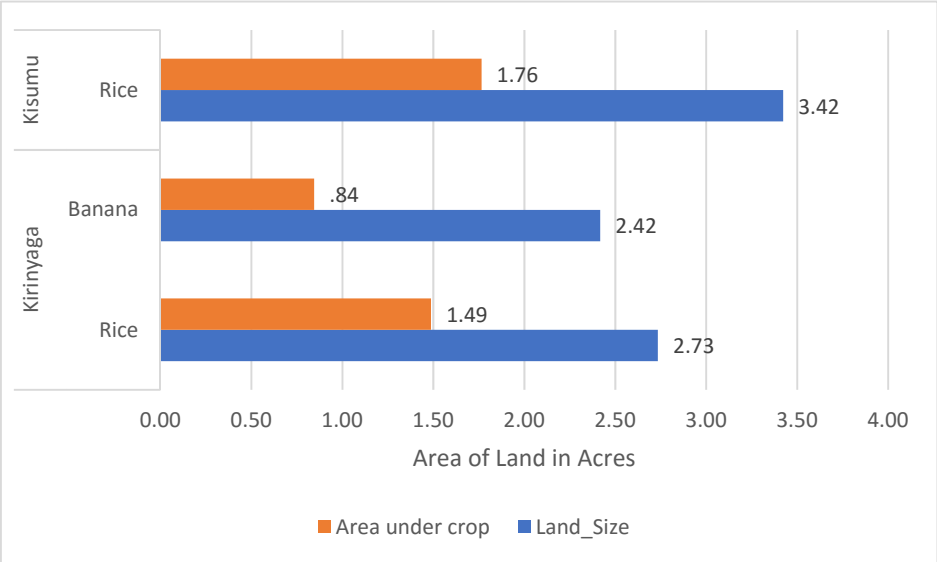

Figure 4: Farm Size Versus Area Under Crops for the Sample Households

This is a great potential for the farmer to use their title deed as collaterals to access financial services. Very few farmers owned or used their communal land for farming (Figure 5).

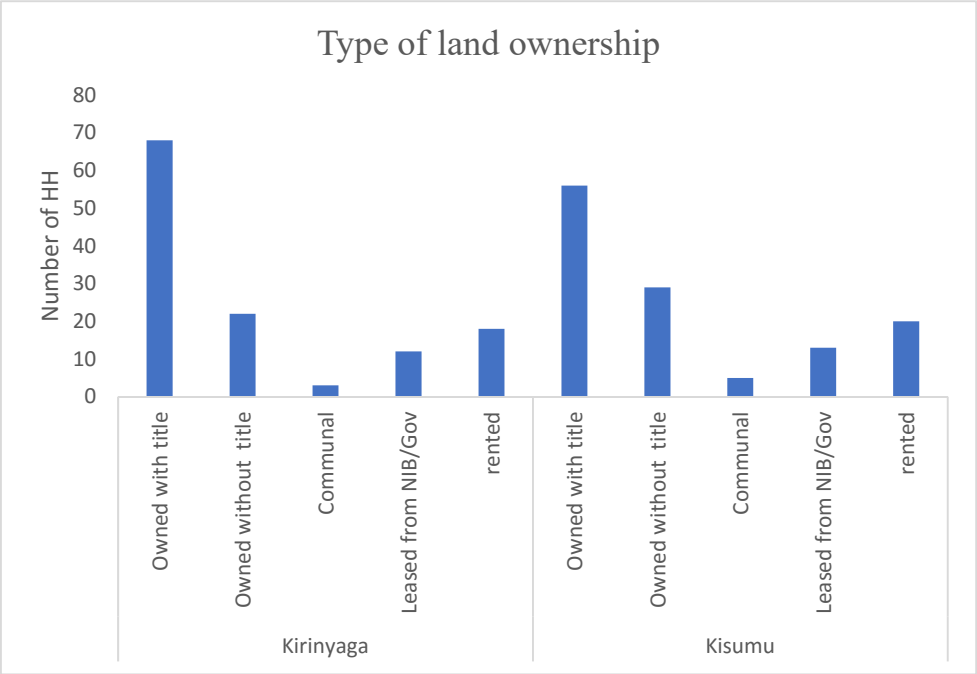

Figure 5: Types of Land Ownership for the Sample Households

- Access to extension and financial services
  In Kenya, extension services are the mandate of the government where farmers are offered services free of charge. However, not all farmers are able to access the services because of the limited number of government extension staff (Table 6).

Table 6: Sources of Extension Services and the Frequency of Access

County	Who provides extension services	Frequency of receiving the extension services			
		Scheduled	Unscheduled (pop in)	Upon request	Total
Kirinyaga	Fellow farmer	2	10	0	12
	NGO	15	9	0	24
	Government institution	27	5	3	35
	Agro vet	0	1	0	1
	Chief's meetings	0	1	0	1
	HCDA	1	0	0	1
	JICA	2	0	0	2
	Kabinga banana growers group	1	0	0	1
	KALRO	1	0	0	1
	MIAD	2	0	0	2
	Rice Map	2	0	0	2
Kisumu	Fellow farmer	5	3	0	8
	NGO	4	5	0	9
	Government institution	26	5	6	37
	AFRITEK	3	0	0	3
	Cooperative society	0	1	0	1
	Beyer crop	1	0	0	1
	Revolving groups	3	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 grouped as commercial bank, micro-finance organizations and cooperatives societies (Figure 6). In Kirinyaga, the main financial institutions that are familiar to farmers (60% of respondents) were commercial banks, while in Kisumu the main institutions were cooperatives societies (Table 7). On average 56% of farmers in Kirinyaga had accessed financial services while in Kisumu County they were 55% (Figure 6).

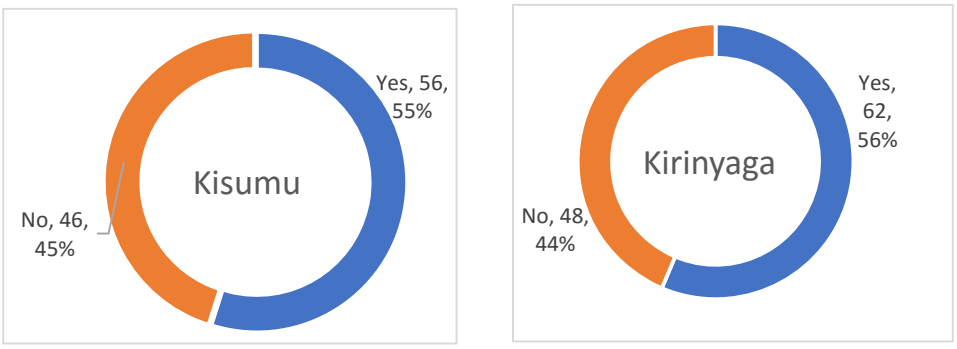

Figure 6: Percentage of Farmers Accessing Financial Services in Kisumu and in Kirinyaga

Table 7: Financial Institutions within Reach of the Sample Households

		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 (40%, N=45 for Kisumu) while in Kirinyaga it was the high cost of financial services (49%, N=41 for Kirinyaga) (Figure 7).

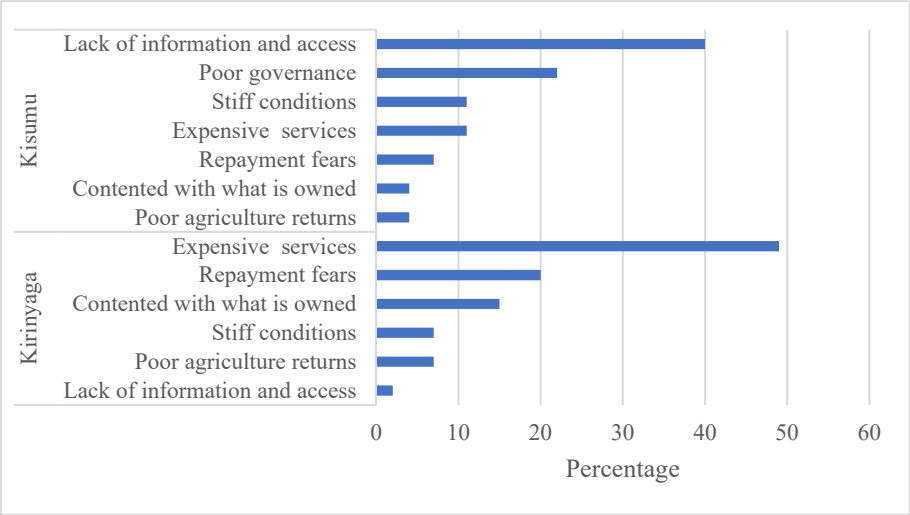

Figure 7: Reasons for not Accessing Financial Services by the Sample Households

- Machinery access

  The adoption and use of agricultural mechanization depends largely on the availability of machinery dealers. However as indicated in Figure 8 below only 35% of the farmers indicated that the dealers were available within their area. Some of the available agricultural machines included; chaff cutters, knapsack sprayers, disc ploughs, water pumps, levellers, millers, ox-ploughs, push weeders, rotavation tractors, rotavators and sprinkles. The average distance from the farm to the dealer was 4.57 Km in Kirinyaga and 5.03 Km in Kisumu.

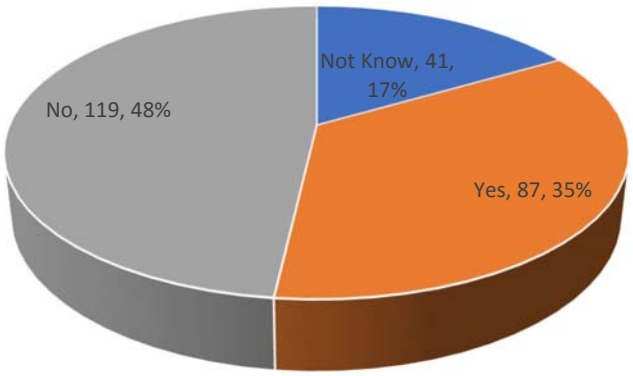

Figure 8: Availability of Agricultural Machinery

- Machinery use

  The extent of mechanization for the rice production in the two counties was found to be high in milling (88%) and transport (84.4%) and moderate in land preparation (66.7%). The operations where mechanization was low were harvesting (9.4%), weeding (5.7%), threshing (5.7%) and fertilizer application (1.6%) (Figure 9). The level of mechanization in pest control indicated that farmers were familiar with the use of sprayers. However, they were not well trained in respect to maximum efficient use of modern machinery.

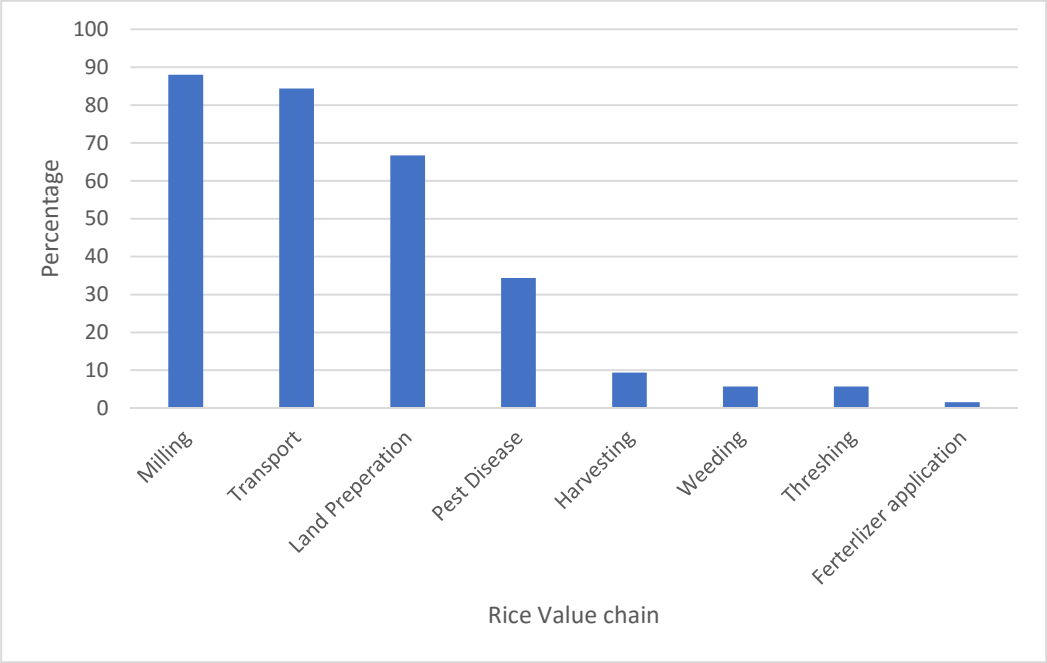

Figure 9: Mechanization Status in the Rice Value Chain

For banana farmers, results showed that almost all (93.2%) of them in Kirinyaga mechanized the transport operations (Figure 10). Use of machinery in land preparations was not as common (only 54.5%) amongst farmers. There was a small proportion of farmers (27.3%) who adopted the use of machinery in processing their bananas e.g. making breads and banana crisps.

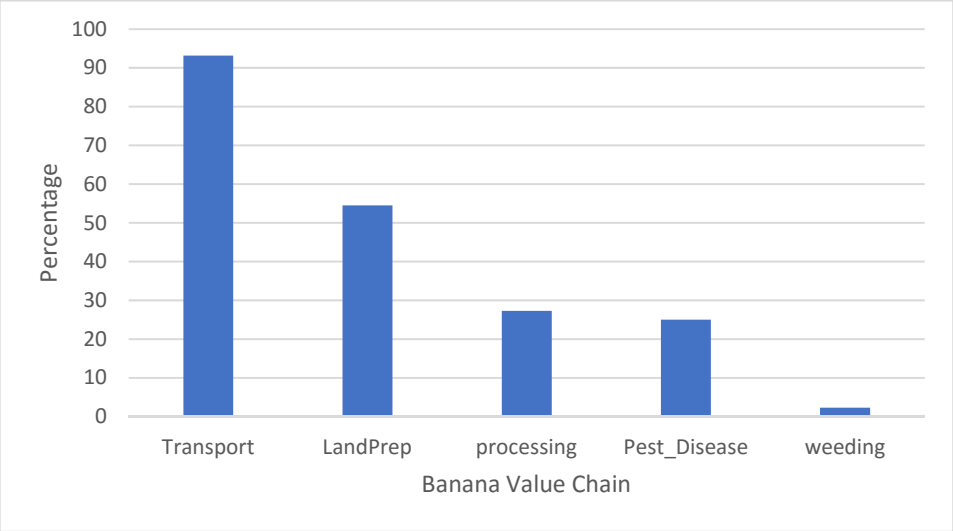

Figure 10: Mechanization Status in the Banana Value Chain

- Determinants of the level of mechanization
  An analysis to identify the factors which determine the level of mechanization and its utilization was undertaken using the probit model where the dependent variable was a binary dummy variable denoted by Level of Farm Mechanization (LFM). There were some operations that were regarded as basic such us transport and milling because of the high likelihood that farmers would mechanize those operations. Therefore, mechanization of only transport and milling or both or none was defined as low level of mechanization. However, mechanization beyond milling and transport were grouped as high level of mechanization. The variable LFM therefore takes the value 1 for high level of mechanizations and 0 for low level of mechanizations. The levels were determined on the basis of the usage pattern of the agricultural equipment in different farm operations. More specifically, the usage of machinery in land preparations, weeding, fertilizer application, pest control, harvesting, threshing and milling/processing were considered as the basis for determining scores of farm mechanization. The set of variables influencing the adoption of farm mechanization consisted of sex of the farmer, level of education, experience of the farmers, access to extension agencies, access to financial services, proportion of area under rice/banana (a proxy for farm size under crop) and agricultural machine ownership. The results of the logit model are shown in Table 8.

Table 8: Results of the Probit Regression Model

Probit regression				**Number of obs**	**=**	**242**
				LR chi2(22)	**=**	**113.01**
				Prob > chi2	**=**	**0**
Log likelihood = -110.56426				**Pseudo R^2**	**=**	**0.3382**
Level of Mechanization		Coef.	Std. Err.	z	P>z	[95% Conf. Interval]
Sex		0.10916	0.225622	0.48	0.629	-0.33305 0.55137
Education						
	2	0.476619	0.450208	1.06	0.290	-0.40577 1.35901
	3	0.292293	0.468133	0.62	0.532	-0.62523 1.209817
	4	0.554342	0.675156	0.82	0.412	-0.76894 1.877623
	5	-0.24785	1.137801	-0.22	0.828	-2.4779 1.982199
Family Size						
	1	0.075463	1.246584	0.06	0.952	-2.3678 2.518722
	2	-0.06078	1.240379	-0.05	0.961	-2.49187 2.370323
	3	-0.28792	1.24613	-0.23	0.817	-2.7303 2.154446
Land Proportion with Crop		0.331557	0.322137	1.03	0.303	-0.29982 0.962933
Extension Services		0.313358	0.217239	1.44	0.049	-0.11242 0.739139
Accessed to financial Services		0.450496	0.214116	2.1	0.035	0.030836 0.870156
Existence of Machinery Dealers		0.390464	0.214123	1.82	0.038	-0.02921 0.810137
Income category						
	2	0.440257	0.279896	1.57	0.116	-0.10833 0.988843
	3	0.703923	0.297281	2.37	0.018	0.121263 1.286583
	4	0.803125	0.269856	2.98	0.003	0.274217 1.332032
Age Group						
	2	0.210191	0.240518	0.87	0.382	-0.26122 0.681599
	3	1.301027	0.53934	2.41	0.016	0.24394 2.358113
Value of Machine category						
	2	-0.04217	0.319651	-0.13	0.895	-0.66868 0.584331
	3	-1.38202	0.300137	-4.6	0.000	-1.97027 -0.79376
	4	-0.72879	0.352338	-2.07	0.039	-1.41936 -0.03822
Value Chain		-1.18569	0.304197	-3.9	0.000	-1.7819 -0.58947
County		0.043591	0.264528	0.16	0.869	-0.47487 0.562056
Constant		0.34929	1.324188	0.26	0.792	-2.24607 2.944651

Availability of machinery dealers had a significant positive impact (Coefficient=0.390464, P-value =0.034) on the level of mechanization. Farm size also contributed to the adoption of mechanization. The results from the model further indicated that the proportion of land under crop had a significant impact on the level of mechanization. In addition, access to financial services showed a significant positive impact on the level of mechanization. This is an indication that high level agricultural mechanization is possible.

Table 9: Marginal Effects of Predictors

	dy/dx	Std. Err.	z	P>z	[95% Conf.	Interval]
Sex	0.028036	0.057817	0.48	0.628	-0.08528	0.141355
Education						
2	0.123412	0.115443	1.07	0.285	-0.10285	0.349677
3	0.075798	0.12045	0.63	0.529	-0.16028	0.311875
4	0.143253	0.172482	0.83	0.406	-0.19481	0.481311
5	-0.06289	0.284585	-0.22	0.825	-0.62067	0.494884
Family Size						
1	0.019207	0.318598	0.06	0.952	-0.60523	0.643646
2	-0.01558	0.317078	-0.05	0.961	-0.63704	0.605881
3	-0.0743	0.318499	-0.23	0.816	-0.69854	0.549952
Land Proportion with Crop	0.085154	0.08229	1.03	0.301	-0.07613	0.246439
Extension Services	0.08048	0.05521	1.46	0.145	-0.02773	0.18869
Accessed to financial Services	0.115701	0.053787	2.15	0.031	0.01028	0.221122
Existence of Machinery Dealers	0.100283	0.054064	1.85	0.034	-0.00568	0.206247
Income category						
2	0.120082	0.075474	1.59	0.112	-0.02784	0.268008
3	0.190928	0.079439	2.4	0.016	0.035231	0.346625
4	0.216821	0.072243	3	0.003	0.075228	0.358415
Age Group						
2	0.05384	0.060773	0.89	0.376	-0.06527	0.172952
3	0.30476	0.105108	2.9	0.004	0.098753	0.510767
Value of Machine Category						
2	-0.01041	0.078763	-0.13	0.895	-0.16479	0.143959
3	-0.39553	0.076329	-5.18	0	-0.54513	-0.24593
4	-0.2025	0.09824	-2.06	0.039	-0.39505	-0.00996
Value Chain	-0.30452	0.070777	-4.3	0	-0.44324	-0.1658
County	0.011196	0.067895	0.16	0.869	-0.12188	0.144268

The result showed that as far as the acceptance of the overall results is concerned the model fits moderately well as the value of pseudo R^2 is 0.34 and the log likelihood ratio is -110.56426.

Conclusions

From the results, it is clear that the level of smallholder farm mechanization in rice fields and banana orchards in Kirinyaga and Ahero Counties is determined by a number of social, economic and agricultural factors which included; gender; insufficient support services through government extension agencies for providing specific information on agricultural mechanization; machinery assets; age group of farmers; low access to institutional credit; and size of land under crop. These factors were found to be the main hindrance for getting the optimum benefits from

the smallholder farm mechanization. Efforts are therefore needed to address these factors for increased adoption and use of modern agricultural machinery in both rice and banana value chains.

To address the constraints in extension services in providing specific information on the use of machinery, extension agents will need to be re-trained on mechanization. In addition, agricultural engineers will have to be employed to provide advisory services on the appropriate agricultural machinery and equipment. Whereas financial institutions have packages for acquisition of machinery, there is lack of awareness amongst many smallholder farmers while those that are aware they are often afraid of using those facilities. Therefore, awareness campaigns will have to be organized through the Ministry of Agriculture, Livestock and Fisheries and other agencies to ensure that farmers utilize such financial facilities. The study also indicated positive effects of size of land holding on the adoption of modern farming machinery. Therefore, specific land reforms in the increasingly commercial value chains will have to be undertaken to ensure maintenance of operational and economic land holdings.

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