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Gender Differentiation in the Analysis of Alternative Farm Mechanization Choices on Small Farms in Kenya

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Abstract

Using multinomial logit we analyze factors that influence the choice of mechanization technologies in Nyanza Province. The results show that farmers are aware of the attributes of the mechanization technologies, and that animal traction is the most commonly used. Gender, formal and informal training of the household head, and technology attributes influence the choice of mechanization technology. This study recommends increased formal and informal training, extension, credit, and tractor hire services to facilitate knowledge transfer, credit, and tractor availability. The study also recommends enactment of laws that increase women's access and control of productive resources.

Keywords: mechanization, technology, gender, choice

JEL classification: Q12, J16, D80, C81, R29, Q18

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1 Introduction

1.1 Background information

About 800 million people, one-sixth of the developing world's total population, are food insecure (Pinstrup-Andersen et al. 2001); 180 million of whom are in sub-Saharan Africa (SSA). The deterioration in SSA's development to some extent reflects the decline in agricultural performance, since agriculture remains the dominant sector of these economies, encompassing over 60 per cent employment, 30 per cent gross domestic product (GDP), and is the main source of foreign exchange (Benneh 1996). But declining per capita food production, increasing food imports, declining or stagnant agricultural exports, and worsening environmental degradation largely define SSA's situation despite considerable investments towards increasing agricultural productivity over the past three decades (Mrema 2000). Kenya, in many respects, closely mirrors the rest of SSA. Its GDP growth rate has steadily declined and was negative (0.3) in 2000 (Republic of Kenya 2001). Although agriculture remains the dominant economic sector, it has been characterized by low and declining productivity. Agriculture's GDP growth rate declined from 4.4 per cent in 1996 to -2.4 per cent in 2000 (Republic of Kenya 2001). Smallholders who account for 98 per cent of total farm holdings contribute most of the sector's output but with poor and inappropriate technologies. Food production has therefore been adversely affected, leading to food deficits and increased reliance on relief food.

Bondo district is among the poorest in Kenya with about half of its population living below the poverty line. The district's population is predominantly young and the level of literacy well below the national average of 80 per cent. Life expectancy is on par with the national average of 51 years but HIV/AIDS infection rates are among the highest in Kenya. Agriculture remains the backbone of the local economy, and over 80 per cent of household income is derived from farming (crop and livestock production) and fishing. The district has a modified equatorial climate strongly influenced by local relief and the nearby expansive Lake Victoria, which influences rainfall amounts and distribution. It predominantly has a warm, dry and humid climate. Less than half (30 per cent) of the arable land potential is utilized for agricultural production. Farming is typically a rain-fed maize mixed farming system. The district is not food self-sufficient hence relies on food purchases from other districts. Opportunities for poverty reduction and economic growth in Bondo district include raising farm productivity (especially labour productivity), reducing exposure to risk, diversifying employment, increasing household incomes, and improving household access to food (Oluoch-Kosura et al. 2003).

Scientific, technological, and managerial innovations and the proper selection, utilization, and management of farm technologies are necessary for productivity improvements. The food insecurity challenge has focused increased attention on the development and dissemination of improved agricultural technologies (Doss and Morris 2001). Unfortunately, significant investments in SSA's agricultural R&D over the past four decades have had limited impact on rural livelihoods, since farmers either failed to adopt or inappropriately applied the technologies. The model of transferring technologies perfected elsewhere has been unsuccessful in many countries (Benneh 1996). The lack of attention to location-specific conditions and expressed customer interests could have made the technologies ineffective, costly, and irrelevant. In Kenya, for instance, agriculture's productivity is below potential (40–60 per cent) and technology adoption is generally low and poor (Oluoch-Kosura et al. 2000). These failures thus raise fundamental questions about technology application especially in rain-fed systems prevalent in SSA. It is generally acknowledged that inadequate attention to needs and preferences of men, women and children in the design and implementation of R&D programmes results in low demand for the technologies (Kabutha 2002).

Farm mechanization is one area that has attracted considerable interest in the field of technology adoption. It is borne out of the recognition that tools, implements, and powered machinery constitute the most important technologies in agriculture. The level, appropriate choice, and subsequent proper use of mechanized inputs in agriculture have a direct and significant effect on production, profitability, and the environment. Mechanization is generally a labour augmenting technology, increasing output per worker rather than output per unit of land. But in situations like Kenya's, where productivity is low partly because of poor timeliness of tillage operations, it may as well be land productivity augmenting. Without land constraints, increased farm power can lead to direct increases in production by increasing the land area or animal numbers per person. Some analysts argue that past failures of agricultural technology investments were because of the neglect of the need for adequate farm power. The hand tools that dominate agriculture could not provide adequate power, yet these technologies demand increased use of farm power. Thus, the low productivity attributed to farm power largely influenced past mechanization models in Kenya, like the rest of SSA, to leap directly to tractors. The potential roles of alternative mechanization methods like animal traction and improved hand tools, among others, were largely ignored.

As a result, despite years of vigorous promotion, the degree of farm mechanization in SSA is currently limited. In Kenya, 30 years of promoting tractor-mechanization has been unsuccessful (Kaumbutho 1996; Oudman 1993). Moreover, belated attempts at promoting animal traction as an alternative are yet to make a significant impact. It is estimated that over 80 per cent of farms in Africa rely on manual tillage and fewer than 16 per cent on animal traction. The African farmer is generally a 'hoe farmer', and is characterized by drudgery, labour supply bottlenecks, and poor timeliness. This has imposed limitations on cropped area and encouraged poor crop husbandry, leading to low productivity. The slow uptake of mechanization technologies, despite these farm power constraints, implies that important factors affecting farmers' decisions are not considered in designing mechanization strategies. Although the technical aspects of mechanization are already widely documented and understood, very little is currently understood of the social, cultural, economic, and environmental factors that influence farmers' mechanization choices.

Engineers and technicians, emphasizing operational technical efficiency of implements, dominate mechanization research. Socio-economists have provided little information on local farming systems to guide the technicians on mechanization technology requirements. As such, mechanization strategies are formulated amidst information gaps on farmer preferences, accessibility, and profitability of alternative small farm mechanization methods. The factors that influence farmers' mechanization choices are not well understood. For instance: what factors determine farmers' preferences for one method over another? Are all the alternative methods feasible and viable on small farms? What variables determine viability? and, what policies and interventions are necessary for increased mechanization? For instance, it is not known whether household characteristics or technology specific attributes are important in choice decisions. That is, do farmers choose technology attributes or are farmer characteristics the determinants of farm mechanization choice? Furthermore, if technology attributes are more important to farmers, do they choose the same attributes across gender? Providing such information would be important in the design of technical research that addresses client needs and for the formulation of policies for increased mechanization and agricultural productivity.

1.2 Objectives of the study

The overall objective of this study is to analyze the factors that influence the choice of farm mechanization technologies at the household level and to suggest policy interventions that would enhance the generation and adoption of appropriate farm mechanization technologies.

The specific objectives are to:

i) characterize the various farm mechanization technologies prevalent in the area.

ii) identify the relevant mechanization technology attributes and estimate their relative influence on their choices by the various households.

iii) determine the categories of households likely to choose given farm mechanization technologies.

iv) determine household (farmer/farm) characteristics that influence the choice of the various farm mechanization technologies, with special focus on gender.

v) determine the effect of institutional and infrastructure factors on the choice of farm mechanization technologies.

2 Methodology

2.1 Conceptual framework

Agricultural mechanization in Africa is characterized by the coexistence of different alternatives in different farming systems. The nature of SSA's agriculture demands that farmers opt for the most appropriate farm mechanization methods when preparing land at the onset of the rain. The choice decisions depend on the circumstances and preferences of individual households, which in turn reflect the features of the farming system and the technologies. This study presumes that farmers choose the attributes embodied in the mechanization technologies rather than the methods per se. However, choice decisions are also affected by the characteristics of individual households in terms of resource endowment and other socio-economic and socio-cultural characteristics. Further, farm mechanization alternatives are heterogeneous and farmers' preferences differ, both within and between households. Decision-makers therefore face different choice sets, evaluate different attributes, and assign different values to the same attribute of the same mechanization technology (Ben-Akiva and Lerman 1985).

The choice of a farm mechanization method is conceptualized as a three-stage decision-making process: identifying the existence of farm mechanization needs; choosing the alternative method to use, and; determining the level of use. The choice of a farm mechanization method is a product of personal characteristics (for example, formal education), which may intensify awareness, and the physical characteristics of the farm. Personal factors, such as training, influence a household's disposition to a particular mechanization method due to awareness of the benefits and costs associated with the mechanization technology. Institutional instruments such as training programmes, technical assistance and cost sharing can influence the choice of particular mechanization methods. Also, relevant public training programmes are likely to heighten perceptions of the importance, costs and benefits associated with the mechanization technology.

In such cases, the decision to choose a particular mechanization technology can be any of four forms: dominance, lexicographic, satisfaction, and utility, which would lead to different choice decisions. However, the most frequently used decision rule or objective is utility maximization. This study uses a discrete choice framework, in which alternative mechanization methods form a discrete set, based on revealed preferences (RP) of individual households.

The basic principle and economic theory behind discrete choice analysis is that the choice of a mechanization technology is a reflection of the technology attributes, which then form the arguments in utility functions (Karugia 1997; Greene 1997; Ben-Akiva and Lerman 1985). In a discrete choice framework, the observed dependent variable usually consists of an indicator of the alternatives most preferred by a household, while the others are considered to be inferior to the chosen option (Greene 1997).

Discrete choice models relate choices of economic agents to appropriate choice sets, consisting of mutually exclusive and collectively exhaustive choices. An operational model consists of parameterized utility functions of observable independent variables and unknown parameters, with values estimated from a sample of observed choices made by households (Ben-Akiva and Lerman 1985). Thus, the attractiveness of an alternative is evaluated in terms of a vector of attribute values, measured either on an ordinal (for example, speed) or cardinal (for example, cost) scale.

2.2 Theoretical basis and the derivation of the multinomial logit model

Probabilistic discrete choice models are frequently based on random utility models (RUM), which are derived from assumptions about individual's evaluations of choice objects. An individual's utility measures are represented by systematic and random components. The systematic component is a function of observed attributes of the alternatives and individuals, while the random component captures variations in choice due to *within* and *between* individual variance, omitted variables, measurement errors and imperfect information (Ben-Akiva and Lerman 1985). The random component is assumed to be independently and identically distributed (IID) according to a particular probability distribution.

Different choice models are obtained by assuming different forms of probability distribution. Two of the frequently assumed probability distributions are the IID Gumbel distribution that yields a multinomial logit model, and the IID normal distribution (multinomial probit model). The multinomial logit model is the most widely used because it is easy to estimate and to interpret. A fundamental property of the logit model is that only differences in representative utility affect the choice probabilities, not their absolute levels. The preferred model for this study is a variant of the MNL called the discrete choice model.

2.3 Data collection and sampling technique

This study uses participatory rural appraisal (PRA) consisting of Focus Group Discussions (FGD) and household interviews in primary data collection, which was undertaken in Bondo district in Nyanza Province, Kenya in 2003. The process of sample selection used PRA tools to identify the technology attributes and the farming systems in the area. FGD involving different sets of farmers were conducted prior to the household interviews to assist in understanding alternative farm mechanization options available in the study area. Primary data was then collected through household interviews using a structured questionnaire.

Data collected include the household (farm/farmer) characteristics, technology specific attributes, and institutional factors. A multistage purposive sampling procedure was used in selecting the respondents to capture mechanization choices and use between the different households. Two divisions from the district were purposively selected; one in the upper mid-land (UM) zone, and the other in the lower mid-land (LM) zone. In the zones, households were stratified by gender of the household head, economic status and cropping systems, among others. A sample of 124 households disaggregated by gender and distributed proportionately between the areas was chosen for the interview. Statistical Package for Social Scientists (SPSS) was used in descriptive statistics analysis. Discrete choice unordered multinomial logit model was used in econometric data analysis.

2.4 Variables used in the regression model

The dependent variable was the multiple farm mechanization methods available to households and the choices they made, namely manual, animal traction, and tractors. The independent variables were in three main groups – technology specific attributes, individual household (farm/farmer) characteristics, and institutional factors.

2.4.1 Technology specific attributes

Availability: measured in terms of the approximate distance to the technology service provider (in kilometres). Power output (time): measured in days taken in land preparation per acre. Profitability: measured as returns attributed to the use of a specific mechanization technology. Gross margins (GM) analysis was used in measuring profitability. Reliability: waiting time (days) after placing an order for tillage service. Efficiency: measured in terms of the number of harrows necessary before planting after using a particular technology and the number of days before the emergence of serious weeds problem. Cost was in US$ per acre of land.

2.4.2 Household (farm/farmer) characteristics

Gender of the household head, Age of the household head in years, Farming experience of the household head: number of years the household head had farmed at the time of the survey. Formal training: number of years spent pursuing formal training. Informal training: number of times attended informal training, for example demonstrations, FFS, farm visits, etc.

Farm size: number of acres under maize-bean enterprise. Off-farm income: amount of money earned from other sources other than the farm in US$.

2.4.3 Institutional factors

Credit service: access to credit or measured by past borrowing from both formal and informal credit sources. Agro ecological zone (AEZ): region where farmer is situated. Infrastructural development index: measured as an index of distance to development facilities such as the nearest divisional administrative offices or markets in kilometres as the base. Commercialization index (farmer's orientation to the market): measured in terms of the proportion of farm output sold.

3 Results and discussions

3.1 Results of descriptive statistics

Households were grouped into different gender categories, that is: male-headed married, male-headed single, and male-headed widower. Other categories include female-headed single, female-headed divorced, female-headed widow and female-headed husband absent. In this study *de facto* female-headed households are those in which husbands live away from home mostly working, while the *de jure* female-headed households are those headed by widows, single, and divorced women. This is necessary because the socio-economic roles of women and men in society are different, which lead to different responsibilities and opportunities that have a bearing on household resource endowment. Consequently, women and men make various choices depending on their social roles, opportunities, and resource endowment.

This study establishes that poor access to farm power is the main constraint facing farming households in Bondo district. Female-headed households, especially *de jure* are the hardest hit, having the most limited access to productive resources such as animal traction. There are strong indications that *de jure* female-headed households are discriminated against in the case of animal traction hire due to their low social status. Furthermore, for those willing to hire, animal traction services are only available after full payment has been made, which means that farmers without adequate lump sum cash do not benefit from animal traction hire services.

Men own and control most of the household productive resources through inheritance and or purchase and the *de jure* female-headed households are most disadvantaged as they in most cases cannot inherit them nor do they have the necessary financial resources to purchase them. In addition, access to animal traction is not necessarily based on gender, but on the availability of cash and the work schedule of the animal traction operator. The *de jure* female-headed households are mostly low-income earners and do not own assets such as livestock and animal traction components. This confines them to the use of manual tillage of tillage. In contrast, *de facto* female-headed households are generally better off since, apart from having access to remittances from their husbands they are more respected in society because of the name and social networks of their husbands. They are therefore able to hire animal traction services or even manual labour for tillage.

Table 1 Household characteristics differentiated by gender

Variable	Whole sample (N=120)	Married MH (N=64)	Single MH (N=7)	Widowed MH (N=6)	*De facto* FH (N=18)	*De jure* FH (N=25)
Age (years)	45	47	24	44	36	53
Formal training (years)	8	9	10	8	8	5
Informal training (occasions)	3	2	2	2	3	2
Farming experience (years)	15	14	3	17	10	24
Per capita income	55,006	70,279	44,483	21,491	47,411	33,846
Household size	5	6	1	3	5	4
Total land size (acres)	3	3.5	0.9	3.8	2.5	2.4
Own land maize-bean enterprise (acres)	1.2	1.3	0.5	1.3	1.0	1.0
Hired land maize-bean enterprise (acres)	0.21	0.3	0	0.1	0.13	0.13
Owned plough (%)	9	14	0	0	5	10

Source: Survey, 2003 (see text, especially section 2.3 Data collection and sampling technique).

Farmers cite delays by animal traction operators as the main reason why they resort to manual tillage. Most farmers who use manual tillage feel helpless and hence resigned to endure the drudgery and tedium of manual tillage. As such, farmers reported that they mostly plant late due to late ploughing occasioned by delays in animal traction services and the tedious nature of manual tillage. Yields and output attributed to manual tillage are low because of late tillage, land area limitations and poor land preparation.

Table 1 shows the various gender categories in which households were classified, and that male-headed households are better off in terms of resource ownership and control, and hence have higher chances of adopting better mechanization technologies than female-headed households. Table 1 also gives a detailed account of the distribution and use of resources and infrastructural access of the various gender categories.

Married male-headed households own more livestock than the average of the sample, followed by the *de jure* and *de facto* female-headed households as seen in Table 2. The most common livestock owned are local zebu cattle, goats, and sheep. Also, married male-headed households own four times as many cattle as the female-headed households. Ownership of improved cattle, which is a sign of wealth, is confined to

Table 2 Mean number of livestock owned by different households

Variable	Whole sample (N=120)	Married MH (N=64)	Single MH (N=7)	Widower MH (N=6)	*De facto* FH (N=18)	*De jure* FH (N=25)
Improved cattle	1	1	0	0	1	0
Local/zebu animals	6	8	2	2	2	3
Sheep and goats	8	10	7	4	5	4

Source: Survey, 2003.

male-headed married and *the de facto* female-headed households. This means that households where men are whether present or absent are better off in terms of household resources than those without the men. It also shows that male-headed single and widower households have fewer resources compared to married households be it male or female headed. This result depicts the economic benefit of men and women combining efforts in investment. The *de jure* female headed households seem to do better in ownership of local zebu cattle compared to the others except the male headed married households. This is because majority of them are widows and they inherited cattle from their dead spouses.

3.2 Land tenure

Table 3 shows that more than half of the sampled households have customary titles with full user rights. However, most of the single male-headed households have customary titles with temporarily user rights. This is attributed to the widespread fear that if young men without families are given full control over land they could sell it. Also there is a lot of rural to urban migration of young people hence not permanent residents in the village. Land tenure insecurity could otherwise discourage the energetic younger people especially the single household heads from investing in agricultural production. Most land in the study area is neither adjudicated nor titled, which means that land can not be used as collateral in accessing credit facilities that could be used to acquire farm mechanization technologies. Focus group discussions revealed that 96 per cent of the land in the study area is inherited from father to son hence there is no threat of eviction being ancestral land a phenomenon that does not encourage households to seek land title deeds. Additionally, the process of acquiring title deeds is expensive and tedious hence discouraging to the mainly resource poor households.

Table 3 Land tenure systems differentiated by gender in percentages

Gender \ Tenure	Private with full user rights	Customary with full user rights	Customary with temporary user rights
Whole sample irrespective of gender	19	76	19
Male HH married	21	79	20
Male HH single	0	57	57
Male HH widower	0	100	33
De facto female HH	16	68	16
De jure females HH	23	73	4

Source: Survey, 2003.

3.2.1 *Availability of labour for farm work*

Table 4 illustrates that on average, five adults and two children are available for farm work per household in the entire sample. Children are however available for farm work after school, on weekends and during school holidays. Also, married and widower male-headed households have the largest pool of farm labour. This implies that these households are more likely to take up labour-intensive technologies compared to the other household categories. The female-headed households have relatively less labour available for farm work. More so, most of them have no adult male in the household, which then imposes heavier burdens on the females since they have to undertake additional household chores besides farm work. All households except the male-headed singles hire labour at an average daily cost of US$0.67. This high cost of labour limits the ability of the mostly resource poor *de jure* female-headed households to adopt labour-intensive farming technologies. Surprisingly, the male headed widower households hire more labour than the rest of the households. This is due to too much work for one pair of hands hence the need to hire additional hands to help.

Table 4 Mean family and hired labour available for farm work, by gender

Variable: available for farm work	Whole sample (N=120)	MHH (married) (N=64)	MHH (single) (N=7)	MHH (widower) (N=6)	*De facto* FHH (N=18)	*De jure* FHH (N=25)
Family adult males	1	1	1	1	0	0
Family adult females	1	1	0	0	1	1
Family children	2	2	0	1	1	1
Hired adults	3	3	0	5	3	3
Total adults	5	5	1	6	4	4
Total children	2	2	0	1	1	1

Source: Survey, 2003.

3.2.2 Access to credit and information

The main source of credit in the study area is informal, such as churches and merry-go-round groups.[1] Generally, there is minimal access to formal credit in the area, especially among the single and widowed male-headed households, and female-headed households especially the *de jure*. Although negligible, a higher percentage of married men have more access to formal credit, mainly because they own and control more valuable assets that are used as collateral, unlike the rest of the household categories. Contrastingly the *de jure* female-headed households have limited control over household productive resources, while the *de facto* female household heads have to consult their absent spouses before making major decisions concerning household assets. Majority of women therefore borrow money from informal sources, which does not require security and if it does, it is not pegged on valuable household assets. The main constrain that face informal credit service providers is the small amounts of money they disburse due to insufficient group funds coupled with the limited capacity of group members to service the loan.

Farmer field schools (FFS) act as major training grounds for farmers.[2] This is a new extension initiative being fronted by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Ministry of Agriculture (2005). FFS revolves around creating a training centre where a group of farmers converge every once in a week to participate in demonstrations on improved farming techniques. The Shifting Focal Area Extension approach is another emerging method of agricultural extension service delivery under the National Agricultural and Livestock Extension Programme (NALEP), supported by the Swedish International Development Agency (Sida), and the Ministries of Agriculture and Livestock and Fisheries Development (Ministry of Agriculture 2005). In this approach extension officers visit a 'focal area' for a period of twelve months, imparting extension knowledge to farmer groups, after which they shift to a new focal area. The purpose is to concentrate the scarce extension resources in an area of about 2,000 households then shift to another area. The most recent effort is the Kenya Agricultural Productivity Project (KAPP),[3] which is a hybrid

[1] A merry-go-round group is one where farmers, mainly women, contribute money and give each other in weekly or monthly rotations or both.

[2] FFS was started in the 1990s and organizes groups of farmers, who assemble at 8am once a week and undertake practical training and demonstrations. The concept originated in the Philippines and was intended to promote integrated pest management in rice farming; it has however been modified to incorporate other crops such as vegetable, sweet potatoes, and maize. Farmers are also engaging in revolving fund loaning activities with small grants (seed money) from the FAO, where farmers borrow money from the group to purchase farm inputs and pay back to the group at the end of the cropping system.

[3] KAPP is a new concept that deviates greatly from past and existing efforts by ensuring transparency and accountability in resource use and service delivery. For instance, under KAPP, one officer is responsible for between one and four groups of farmers. These farmers have a common interest in an enterprise that falls within their area of expertise. Farmers are advanced a grant of about US$1,000 to purchase extension services, demonstration, and training materials. Farmers pay for extension services from the service provider (the 'expert') and buy their own training materials. The officer is responsible for ensuring that there is increased productivity within their group, and is thus personally accountable to the success of the group.

Table 5 Access to credit and information (%)

Variable	Whole sample (N=120)	MHH married (N=63)	MHH single (N=7)	MHH widowed (N=6)	*De facto* FHH (N=18)	*De jure* FHH (N=25)
Formal credit	6	8	0	0	6	4
Informal credit	24	19	0	33	47	24
Attend FFS	44	50	57	33	37	35

Source: Survey, 2003.

of various extension approaches and methods on a pilot phase of three years. KAPP deviates from NALEP in that although it works with common interest farmer groups, KAPP stays in a focal area for three years. Farmers are focused upon increasing productivity through setting and achieving agreed-to performance targets. It is expected that KAPP will revolutionize agriculture and contribute significantly to productivity.

Table 5 shows that about half of the married and single men attend FFS. However, fewer women attend the schools, because of their obligations to household chores alongside farm work. Therefore, women again are unlikely to benefit from the new extension approach. Female-headed households both *de jure* and *de facto* are the main beneficiaries from informal credit services. This is so because women are more organized in groups that engage in financial activities, while men either join women's (merry-go-round) groups or they belong to no group at all.

3.2.3 Mechanization methods

Animal traction is the most commonly used tillage method, followed by manual tillage, as seen in Table 6. Animal traction is fast, efficient, and relatively affordable besides being readily available in the area. Eighty-two per cent of households use animal traction, while 7 per cent use manual tillage. Notably, more than half of the farmers in each gender category use animal traction. More married and widowed male, and the *de facto* female-headed households use animal traction, because married men own more household resources such as livestock, ploughs, and income, and are hence able to invest in animal traction. More households use animal traction because they appreciate its efficiency, availability, and relatively low cost. Households who do not use animal traction are the very poor who cannot afford the technology or those with very small plots of land that does not facilitate the movement of equipment and animals.

The *de facto* female-headed households are limited in decision making because although they have access to household resources, the absent spouse has to be consulted before major farm decisions are made. This leads to delays in the implementation of farm activities (Joekes and Pointing 1991). The *de jure* female-headed households, apart from owning fewer household resources they have to rely on men to operate the animal traction technology. This is because the design of the implements discourages the participation of women.

Generally, more male-headed households operate animal traction than female-headed households because of the prevailing socio-cultural practices and traditional beliefs that

Table 6 Mechanization methods used, by households (%)

Mechanization method	Whole sample (N=120)	MH married (N=63)	MHH single (N=7)	MHH widowed (N=6)	*De facto* FHH (N=18)	*De jure* FHH (N=25)
Manual tillage	18	11	29	17	17	29
Animal traction	81	89	71	83	83	67
Zero tillage	1	0	0	0	0	4
Total	100	100	100	100	100	100

Source: Survey results, 2003.

discourage women from owning and operating animal traction technology. Furthermore, women generally have lower levels of formal and informal training coupled with a lack of access to formal credit, which constrain their access to the more expensive animal traction compared to manual tillage.

3.3 Results of econometric analysis

3.3.1 Effects of household socioeconomic characteristics on the choice of mechanization

Formal training positively influence the use of animal traction in the whole sample irrespective of gender, while age of the household head has a negative influence on the use of the same technology (Table 7). This is because trained farmers are less risk

Table 7 Factors influencing choice of mechanization methods for the whole sample

	Animal traction				Manual			
Variable	Coeff.	SE	T-ratio	P-value	Coeff.	SE	T-ratio	P-value
Gender	-0.084	0.058	-1.721	0.104	0.634	0.283	2.234	0.025**
Age	-0.871	0.532	-1.642	0.101	0.357	0.150	2.011	0.025**
Formal training	0.110	0.055	2.004	0.045**	-0.112	0.059	-2.001	0.044**
Informal training	0.070	0.232	0.299	0.765	-0.046	0.249	-0.185	0.853
Off farm income	0.003	0.003	1.653	0.115	0.001	0.001	1.525	0.105
Land size	0.946	0.131	0.723	0.126	-0.493	0.306	-1.661	0.104
Credit	0.611	0 .330	1.855	0.064	0.084	0.140	0.603	0.546
Commercial index	0.043	0.485	0.090	0.927	-0.930	0.591	-1.582	0.114
Infrastructure index	-0.007	0.017	-0.376	0.722	0.009	0.019	0.443	0.658

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively.
Source: Survey, 2003.

averse, and training increases the ability to comprehend the technology attributes, thereby influencing choice. But male-headed households use animal traction more than female household heads due to their higher resource endowment. Formal training has a negative influence on the use of manual tillage, implying that farmers with less training use manual tillage more so than those with more training who prefer animal traction. This is attributed to increased access to resources and information that come from training. The gender of the household head also influences the use of manual tillage. That more female-headed households use manual tillage than male-headed households is also attributed to differences in resource endowment in favour of men.

The commercialization index has a negative influence on the use of manual tillage, implying that the less market-oriented farmers use manual tillage more that market oriented households. However, this result requires cautious interpretation because of the possibilities of reverse causality. As manual tillage is tedious and thus prone to delay tillage operations, it is likely that households that use manual tillage do not produce enough for sale due to low yields coupled with their small farm sizes. Therefore, age, gender, and the level of training of the household head influence mechanization choices. On the other hand, the age of the household head has a positive influence on the choice of manual tillage implying that houses managed by older heads use more manual tillage than their younger counterparts.

Table 8 reveals that formal training and off farm income have a positive influence on the choice of animal traction among married male-headed households. This is so because training acts as a source of information while income acts as a means of acquiring farm mechanization technologies. The two combine well to facilitate the farmer's access to animal traction technology among the married male-headed households. On the other hand, the age of the household head has a negative influence on the use of animal traction, which implies that younger and more adventurous farmers engage more in the use of animal traction. One interesting observation is that access to formal credit has a negative influence on the use of animal traction, which is attributed to the low amounts of money borrowed mainly from the informal sector. On the part of manual tillage, the infrastructure index positively influences the choice among married male-headed households. This observation is a result of the difficulty encountered in accessing information on mechanization given the long distances involved. This implies that households who live further from service centres such as government offices and markets use more manual tillage than those who live closer. However, land size and formal training have a negative influence on the use of manual tillage. Farmers with more years of training and those who own more land use the more efficient animal traction at the expense of manual tillage.

Table 8 Factors influencing choice of mechanization methods among the married male-headed households

Variable	Coeff.	SE	T-ratio	P-value
		Animal traction		
AEZ	0.058	0.346	0.170	0.864
Age	-0.019	0.019	-1.545	0.113
Formal training	1.186	0.402	2.946	0.003***
Informal training	0.245	0.308	0.800	0.423
Off farm income	0.001	0.001	1.588	0.135
Land size	0.094	0.164	0.572	0.567
Formal credit	-0.623	0.411	-1.526	0.127
Commercial index	0.449	0.648	0.692	0.489
Infrastructure index	-0.002	0.047	-0.062	0.950
		Manual		
AEZ	0.149	0.375	0.399	0.689
Age	-0.011	0.197	-0.597	0.550
Formal training	-0.137	0.093	-1.679	0.119
Informal training	0.231	0.321	0.720	0.471
Off farm income	0.001	0.001	0.890	0.373
Land size	-0.973	0.763	-1.627	0.117
Formal credit	0.340	0.430	0.788	0.430
Commercial index	0.52	0.669	0.778	0.436
Infrastructure index	3.118	1.558	2.005	0.045**

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively. AEZ = agro ecological zone.

Source: Survey, 2003.

Formal and informal training positively influence the use of animal traction while the infrastructure index negatively influences the use of the same technology among single male-headed households. This implies that better (formal and informal) trained farmers choose to use animal traction because they are able to rationally asses the benefits and risks attributed to the technology compared to their less trained counterparts. Also, land size and formal training have a negative influence on the use of manual tillage. This means that households with more training and those who have larger plots of land use less manual tillage. These households are likely to have a better understanding of the

Table 9 Factors influencing choice of mechanization methods among single male-headed households

	Animal traction				Manual			
Variable	Coeff.	SE	T-ratio	P-value	Coeff.	SE	T-ratio	P-value
AEZ	0.047	0.045	1.044	0.296	0.772	0.539	1.431	0.113
Age	0.967	0.557	1.736	0.083	6.735	4.249	1.585	0.113
Formal training	2.132	1.065	2.001	0.0454**	-2.195	1.300	-1.689	0.091
Informal training	0.321	0.082	3.913	0.001***	0.480	0.438	1.095	0.273
Off farm income	0.001	0.001	1.044	0.296	-0.001	0.001	-0.618	0.536
Land size	2.896	1.990	1.455	0.146	-0.659	0.276	-2.385	0.017**
Forma credit	0.623	0.411	1.026	0.327	4.870	3.600	1.353	0.176
Commercial index	12.685	8.043	1.577	0.115	15.200	8.870	1.221	0.336
Infrastructure index	-0.669	0.265	-2.526	0.011**	0.166	0.262	0.634	0.526

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively. AEZ = agro ecological zone.

Source: Survey, 2003.

technology attributes and more resources to invest in expensive but efficient animal traction. Additionally, larger land sizes provide adequate space for the movement of animals and people (Table 9).

Formal and informal trainings, land size, age, and commercialisation index positively influence the choice of animal traction as a tillage option among the *de jure* female-headed households as seen in Table 10. Training builds the capacity of household heads enabling them to comprehend and invest in the relatively more efficient but affordable animal traction option. They also find it more cost effective to use animal traction option where land is relatively larger. Interestingly, unlike in previous observations, older household heads use animal traction more than their younger counterparts among the *de jure* female-headed households. Those women in this category, who have received more years of training and have larger farm sizes, use animal traction more than those who have less years of training and have smaller land sizes. This means that training helps the *de jure* female-household heads to choose the more effective animal traction option.

Table 10 Factors influencing choice of mechanization methods among the *de jure* female-headed households

Variable	Coeff.	SE	T-ratio	P-value
		Animal draught power		
AEZ	-0.180	0.760	-0.211	0.817
Age	0.308	0.206	1.596	0.115
Formal training	0.700	0.366	2.511	0.015**
Informal training	1.293	0 .793	1.631	0.103
Off farm income	0.001	0.001	0.490	0.624
Land size	0.720	0.278	2.584	0.010***
Formal credit	2.797	2.448	1.143	0.253
Commercial index	15.207	8.874	1.714	0.087
Infrastructure index	0.221	0.175	1.269	0.204
		Manual		
AEZ	-0.287	1.934	-0.148	0.882
Age	-0.018	0.045	-0.115	0.780
Formal training	-0.070	0.180	-0.391	0.696
Informal training	-0.021	0.102	-0.209	0.834
Off farm income	-0.051	0.432	-0.117	0.907
Land size	0.029	1.194	0.025	0.980
Formal credit	-1.293	0.793	-1.63	0.103
Commercial index	-1.114	0.426	-2.620	0.008***
Infrastructure index	0.241	0.377	0.637	0.572

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively. AEZ = agro ecological zone.

Source: Survey, 2003.

Table 11 shows that years of formal and informal training and off farm income positively influence the choice of animal traction among the *de facto* female-headed households. The information gained from training together with the presence (albeit absent) of a man in the household makes the situation of the household better in terms of information access and resource endowment hence the choice of animal traction. However, unlike previous observations, infrastructure index has a negative influence on the choice of manual tillage among the *de facto* female-headed households. This implies that farmers who live close to the infrastructure facilities use manual tillage more than those who live far off.

Table 11 Factors influencing choice of mechanization methods among the *de facto* female-headed household

Variable	Coeff.	SE	T-ratio	P-value
		Animal traction		
AEZ	0.328	0.494	0.666	0.506
Age	-0.09	0.031	-0.298	0.766
Formal training	1.684	0.484	3.477	0.001***
Informal training	3.118	1.558	2.001	0.045**
Off farm income	0.001	0.001	1.573	0.141
Land size	0.084	0.140	0.603	0.546
Formal credit	0.472	1.112	0.426	0.682
Commercial index	0.981	0.911	1.077	0.281
Infrastructure index	-0.018	0.107	-0.172	0.863
		Manual		
AEZ	1.118	1.115	1.108	0.270
Age	-0.071	0.322	-0.210	0.838
Formal training	0.308	0.206	1.596	0.135
Informal training	-0.171	0.340	-0.503	0.515
Off farm income	0.197	0.391	0.503	0.615
Land size	-0.001	0.001	-0.490	0.624
Formal credit	-1.211	0.688	-1.788	0.074
Commercial index	-2.981	2.542	-1.123	0.244
Infrastructure index	-3.118	1.558	-2.010	0.044**

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively. AEZ = agro ecological zone.

Source: Survey, 2003.

The age of the household head and off farm income positively influences the use of animal traction among widower male-headed households (Table 12). This implies that older male-headed household widowers use more animal traction than their younger counterparts. This is attributed to the higher resource endowment that the older widows enjoy from inheritance and also from remittances from their children. On the other hand, years of training, land size and commercialisation index have a negative influence on the use manual tillage. This implies that farmers who have received more training engage less in the use of manual tillage.

Table 12 Factors influencing choice of mechanization methods among male-headed households (widowers)

	Animal traction				Manual			
Variable	Coeff.	SE	T-ratio	P-value	Coeff.	SE	T-ratio	P-value
AEZ	0.123	0.258	0.476	0.634	0.149	0.375	0.399	0.689
Age	0.165	0.042	3.942	0.000***	-0.011	0.197	-0.597	0.550
Formal training	0.123	0.156	0.791	0.429	-1.114	0.426	-2.615	0.009***
Informal training	0.245	0.308	0.800	0.423	0.231	0.321	0.720	0.471
Off farm income	0.001	0.001	1.612	0.098	0.001	0.001	0.890	0.373
Land size	0.109	0.350	0.311	0.755	-0.668	0.265	-2.521	0.012**
Formal credit	0.605	0.830	0.729	0.466	0.340	0.430	0.788	0.430
Commercial index	0.955	0.565	0.692	1.691	-1.821	1.513	-1.503	0.098
Infrastructure index	-0.006	0.068	-0.091	0.927	0.057	0.071	0.809	0.419

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively. AEZ = agro ecological zone.

Source: Survey, 2003.

3.3.3 *Technology attributes preferred by households*

Table 13 shows that animal traction is twice as profitable as manual tillage for all gender categories. The number of harrows before planting is the same for both animal traction and manual tillage for all gender categories. Interestingly weeds emerged earlier

Table 13 Means of different technology attributes preferred by households

	Married MH	Single MH	Widower MH	*De facto* FH	*De jure* FH
	Animal traction				
Profitability (US$)	172.95	150.45	144	135.56	130
Number of harrows	1	1	1	1	1
Weed emergence (days)	9	9	9	10	10
Cost (US$)	12	13.33	16	17.33	20
Power output (days)	3	3	3	3	3
Distance to supplier (km)	1	1	1	1	3
	Manual tillage				
Profitability (US$)	75.96	69.88	32.40	60.99	44.27
Number of harrows	1	1	1	1	1
Weed emergence (days)	14	12	14	14	14
Cost (US$)	12	11.33	14.67	13.33	15.33
Power output (days)	11	10	12	15	16
Distance to supplier (km)	—	—	—	—	—

Source: Survey, 2003.

where animal traction was used compared to where manual tillage was undertaken which is explained by the finer quality of operation achieved under manual tillage compared to the rougher animal traction. The cost of animal traction and manual is the same for the male headed married households but it is higher for animal traction compared to manual among the rest of the households. Animal traction is the same for all households but it is much higher that manual tillage. This so because the operators of the animal traction are the same for both male and female headed households because the technology comes with its operators when hired. Manual tillage power is the highest among the *de jure* female-headed households and lowest among the male-headed married households. Distance to the source of animal traction is within 1 km for all households irrespective of gender. The implications are that animal traction technology is within the reach of the households only being constrained by its high cost and the congested schedule due to high demand.

3.3.4 Technology attributes influencing the choice of mechanization method

As seen in Table 14, the time taken before serious weed emergence together with the profitability attributed to the technology have a positive influence on the choice of that technology. But cost and power output of a technology has a negative influence on the choice of that mechanization method. Power output was measured in the number of days taken to complete a task hence the more days it takes the lower its power output.

Table 14 Technology attributes influencing choice of mechanization in the whole sample

Variable	Coeff.	SE	B/SE	P-value
Supplier distance	-0.078	0.038	-1.542	0.1181
Harrows number	-0.287	0.455	-0.630	0.529
Weed emergence	0.0264	0.0079	3.345	0.0008***
Cost	-0.00057	0.00023	-2.474	0.0134**
Profit	0.0019	0.001	1.963	0.0534*
Power output	-0.085	0.084	-1.563	0.1045

Notes: ***, **, * significant at the 1%, 5%, 10% level of error probability respectively.
Log-L for choice model = -4.233; R^2 = 0.55756; chi^2 = 12.63645; significance for chi^2 = 0.87501.
Source: Survey results, 2003.

Profitability attributed to a technology has a positive influence on the choice of that technology among both married and single male-headed households as seen in Table 15a. On the other hand cost, number of harrows before serious weed emergence, and power output has a negative influence on the choice of a technology among both male-headed married and single households.

Table 15a Technology attributes influencing choice of mechanization methods differentiated by gender (multinomial logit MLE)

	Male-headed households married				Male-headed households single			
Variable	Coeff.	SE	B/SE	P-value	Coeff.	SE	B/SE	P-value
Supplier distance	-0.047	0.034	-1.641	0.047	-0.177	0.125	-1.418	0.156
Harrows number	-1.186	0.402	-2.946	0.003***	-0.286	0.455	-0.630	-0.529
Weed emergence	0.133	0.539	0.247	0.805	0.048	0.038	1.247	0.212
Cost	-0.001	0.001	-1.973	0.055*	-0.001	0.000	-2.094	0.036**
Profit	0.002	0.001	1.967	0.054*	0.002	0.001	1.972	0.021**
Power output	-0.047	0.034	-1.641	-0.047	-3.118	1.559	-2.001	0.031**
	Log-L for choice model = -22.9861; R^2 = 41.5888; chi^2 = 11.04400; significance for chi^2 = 0.80078.				Log-L for choice model = -11.6996; R^2 = 52.562; chi^2 = 12.53645; significance for chi^2 = 0.867501.			

Notes: ***, **, * Significant at the 1%, 5%, 10% level of error probability respectively

Source: Survey results, 2003

Table 15b shows that the cost of a technology and its power output has a negative influence on the choice of that technology among male-headed widower households. Also, profitability of a technology has a positive influence to its choice. For the *de jure* female-headed households, the number of harrows, cost, and distance to the supplier of the technology has a negative influence on the choice of the technology. This implies that households prefer efficient but affordable technologies.

Table 15b Technology attributes influencing choice of mechanization methods differentiated by gender (multinomial logit MLE)

	Male-headed households widower				*De jure* female-headed households			
Variable	Coeff.	SE	B/SE	P-value	Coeff.	SE	B/SE	P-value
Supplier distance	0.081	0.079	1.026	0.305	-0.186	0.119	-1.555	0.119
Harrows number	0.286	0.455	0.630	0.529	-0.021	0.006	3.379	0.001***
Weed emergence	0.048	0.038	1.274	0.212	0.155	0.123	1.252	0.211
Cost	-0.002	0.001	-1.972	0.020**	-0.001	0.001	-2.501	0.012**
Profit	0.000	0.000	1.593	0.1123	0.001	0.001	1.524	0.127
Power output	-1.005	0.520	-1.968	0.015**	2.371	0.345	0.687	0.492
	Log-L for choice model = -11.5996; R^2 =55.961; chi^2 = 12.63645; significance for chi^2 = 0.87501				Log-L for choice model = -20.73; R^2 =51.265; chi^2 = 11.63645; significance for chi^2 = 0.82630			

Note: ***, **, * Significant at the 1%, 5%, 10% level of error probability respectively.

Source: Survey results, 2003

Table 15c shows that the numbers of days taken before serious weeds emerge after the use of a technology, and profitability attributed to the use of that technology, have a positive influence on the choice of a technology among the *de facto* female headed households. These are preferred because tillage operations are widely spaced, which reduce the costs. Also farmers being rational consumers will go for technologies that increase their profits. But number of harrows required before planting after the use of the technology together with its cost has a negative influence on the choice of that technology among the *de facto* female-headed households. Increased harrowing increases cost of tillage hence not preferred by many rational farmers, hence farmers go for technologies, which are more efficient and cost effective.

Table 15c Technology attributes influencing choice of mechanization methods differentiated

De facto female headed households				
Variable	Coeff.	SE	B/SE	P-value
Supplier distance	-0.129	0.510	-0.253	0.800
Harrows number	-0.023	0.008	-2.740	0.006***
Weed emergence	0.167	0.056	2.969	0.003***
Cost	-0.002	0.001	-1.549	0.121
Profit	0.003	0.001	1.981	0.058*
Power output	0.645	0.534	1.215	0.187

***, **, * Significant at the 1%, 5%, 10% level of error probability respectively

Log-L for Choice model = -4.375; R^2 = 0.556; chi^2 = 12.63645; significance for chi^2 = 0.8063

Source: Survey results, 2003.

4 Conclusions and policy implications

4.1 Conclusions

The study reveals that farmers are generally aware of the various farm mechanization methods prevalent in the district. The most commonly used tillage methods are manual and animal traction. Households prefer animal traction due to its efficacy, availability, and relative affordability, and hence is the most suitable mechanization method in the area. However, the very low-income households and those who own very small parcels of land use manual tillage since they cannot afford animal traction, which is more expensive than manual tillage. Households with small plots of land use manual tillage because animal traction requires space (clearance) for the movement of animals and equipment. The choice of manual tillage is however most prevalent among the *de jure* female-headed households.

Generally, there are differences in resource availability and ownership with a tilt against women, more so the *de jure* female headed households, which limit their farm productivity. The choices that male and female household heads make on farm mechanization are differentially influenced by the household's socio-economic characteristics and technology attributes. This is so because characteristics such as the level of training, land and livestock ownership and being married, single or divorced for instance imply different opportunities and challenges in society.

Male-headed households are better trained, own and control more household resources than their female counterparts. Also, male-headed households attend FFS more than female-headed households due to the burden of farm and other domestic chores undertaken by the female members of the community. Access to formal credit is very minimal in the district, which is confined to male-headed married and female-headed households. However, male-headed married households together with the female-headed households have limited access to formal credit, while female-headed households have more access to informal credit, as women groups in which they are members mainly operate informal credit.

Formal and informal training, land size, and the age of the household head promote the use of animal traction. The same factors discourage the use of manual tillage across gender. Training increases awareness, while land size determines whether animals and equipment have space to be used. High cost also discourages the use of a technology, while power output and profitability promote the use of the technology. Therefore farmers seek technologies, which are profitable, affordable, and efficient at the least possible cost.

4.2 Policy implications and recommendations

Formal and informal training promotes the use of animal traction, which is a suitable farm mechanization technology for the resource poor smallholder farmers. The training curriculum of the Ministry of Agriculture should emphasize mechanization topics to inform farmers on alternative farm mechanization options. Small hand pushed tractors mainly used in the Asian countries should be introduced and promoted to increase the alternatives for farm mechanization in Kenya and in Bondo district especially for those households with smaller land holdings.

Technology attributes such as efficiency, power output, and reliability promote the use of animal traction technology. But all members of society do not access animal traction. Consequently, more research needs to be undertaken to develop hand implements that are more efficient and cost effective to address the needs of this category of household. Alternatives such as the two-wheeled hand pushed tractors should be introduced and demonstrated to households to create awareness. Research should also incorporate farmers' desirable attributes such as low cost and high power output into existing technologies to make them more appropriate.

All household resources including tillage equipment are owned and controlled by men; thus women cannot make decisions concerning these assets. Gender issues should be included in farmer training and the extension officers' training curriculum to sensitize them to gender so as to encourage equity. The government through parliament should enact legislative laws that will promote gender equity. Community leaders such as politicians should be sensitive to gender equity so that they can impart appreciation to their communities.

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